MAY 1960

SAE

PUBLISHED BY THE SOCIETY OF AUTOMOTIVE ENGINEERS

JOURNAL

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Briefs of SAE PAPERS

These digests are provided by ENGINEERING INDEX, which each year abstracts 30,000 engineering articles from 1500 different publications and classifies them into 249 "fields of engineering interest."

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AIRCRAFT

F-106 Multiple Power Generating System, P. W. CORBETT, R. K. WALTER. Paper No. 128A. Consideration of aircraft, mission, environment, electrical and mechanical requirements in development of power generating system for Convair's fighter interceptor by General Dynamics Corp.; details of configuration and MA-1 weapons system; outstanding features of power generating system; electrical multiplicity, i.e., one drive, four generators, eight electrical systems, etc.; maintained frequency control of plus or minus 5%.

Integration of Constant Speed Drive with Weapon System, A. V. CHAVEZ, J. L. BURGESS. Paper No. 128B. Approach used by Boeing Airplant Co. in developing constant speed drive, based on methods used in B-47 and B-52 aircraft programs; systems include 40-kva "hard drive" systems for B-52; step-by-step procedure through mechanics by which fully qualified drive may be obtained and how it may be integrated with weapon system.

Specification Requirements for USAF Engine Driven Constant Speed Alternator Drives, R. A. NOVOTNY. Paper No. 128C. Current practice of designing constant speed drive to meet requirements of each weapon system is explained and Air Force constant speed drive requirements are outlined in regard to capacity, output speed regulation, load division, protective devices, oil system, zero "G" conditions, efficiency, and weight; areas are indicated where requirements will change to meet future demands.

Constant Speed Drive Starter Units, P. R. WOOD. Paper No. 128D. Unit combining engine starter and low heat rejection constant speed drive, developed by AiResearch Manufacturing Co. of Arizona, consists of generator, gear system, including starting brake, and starting turbine; operating principle provides three different modes of operation: main engine starting from turbine power, constant speed operation from turbine power alone, and constant speed operation from main engine shaft power with turbine speed control.

Matching Constant Speed Drive to Specific Application, C. D. FLANIGEN. Paper No. 128E. Approach used by Lycoming Div. of Avco Corp. in study of complete drive development program; establishment of design area is described by applying quantitative values, where possible, to following detail requirements: type of drive desired; time and money involved; weight and space; temperature and vibration environments; power capability; frequency control performance, and special features required; suggestions made.

Design of Hydro-Mechanical Constant Speed Drive for 120 KVA Generator, P. C. MOSHER, L. B. HALLIBERG. Paper No. 128F. Development of 120-Kva constant speed drive by Sunstrand Aviation, Rockford, Ill., utilizing hydromechanical transmission; outstanding features are use of fabricated 347 stainless steel housing; high speed bearings; improved control system in regard to governor performance; frequency and load controller and frequency reference design, and current transformer accuracy; selection of components; design problems.

Design and Performance of Constant Speed Drives for Commercial Use, R. H.

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Briefs of SAE PAPERS

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GUEDET. **Paper No. 128G.** Design criteria of General Electric 40-kva constant speed drive for Convair 880 and 600 jetliners, designed for commercial use; mechanical hydraulic transmission consists of variable stroke hydraulic pump motor coupled to fixed displacement hydraulic pump motor; testing program and flight testing; efficiency of drive varies from 82% to 90% at rated load of 64 hp; at load of 32 hp, efficiency varies from 75% to 83%; other performance data.

Up in Air with Business, H. W. BOGGESS. Paper No. 136A. Use of business aircraft fleet and problems involved which have to be faced by business; problems include asquisition, operation, maintenance, scheduling, and efficient utilization of company owned aircraft; methods employed by organization which operates fleet of 20 airplanes.

Small Company Uses Airplanes, G. F. DRAKE. Paper No. 136B. Three company owned aircraft are employed by Woodward Governor Co., Rockford, Ill.; procedure used and general company attitude toward these aircraft; operating costs and tabulation of figures which include charges for maintenance, storage, fuel and oil, insurance and capital depreciation for three types of aircraft used.

General Aviation During Soaring Sixties, D. ROSKAM. Paper No. 136C. Growth of air transportation with particular reference to use of company- and individually-owned personal aircraft and its implications; possible future trends.

Integration of Missile Ground Support Equipment, I. TROWBRIDGE, W. B. VAN HORNE. Paper No. 138A. Factors to consider in design of ground support system include weapon design, operational maintenance, logistics, and personnel concept; based on requirements derived from these concepts, analytical procedures provide type specification for support system; analysis of subsystem performance specifications, and detailed design; test and evaluation determine utility of synthesized system when compared with initial requirements.

Launcher Shelters for BOMARC, R. V. OSTLING, P. M. KELLY. Paper No. 138B. Design of launcher shelters for defense missile such as BOMARC (Boeing — Univ. Michigan Aeronautical Research Center) is greatly influenced by weapon system readiness requirement; direction of progress in design was to maintain this capability while reducing shelter size, quantity of construction materials and costs; steps taken in developing five shelter design models; comparison of designs and costs.

Surge Characteristics of Aircraft Underwing Fueling — By-Product of Pressure Fueling, R. H. K. CRAMER, D. L. DAVIS. Paper No. 139A. Basic features of DC-8 fuel system and equipment; mathematical analysis of expected surge pressures in fueling operation; test programs undertaken to study operating conditions of DC-8 system and sources of fueling irregularities; probable causes of surges induced by start-up surge, back-flow surge, and fill valve shut-off induced surges; measures taken with respect to airlines operating DC-8's; parameters covering fueling equipment.

Landing Gear and Tire Experience with Boeing 707, W. P. ERICKSEN. Paper No. 139B. Details of landing gear of Boeing 707, made primarily of high strength steel; automatic braking system for stopping wheel rotation after takeoff and prior to gear retraction; use of forged aluminum wheels; installation of fuse plugs in wheels to release air pressure at predetermined elevated temperature, prior to tire bursting; tire service life; maintenance procedures and operating instructions.

Control Techniques for Reliability,

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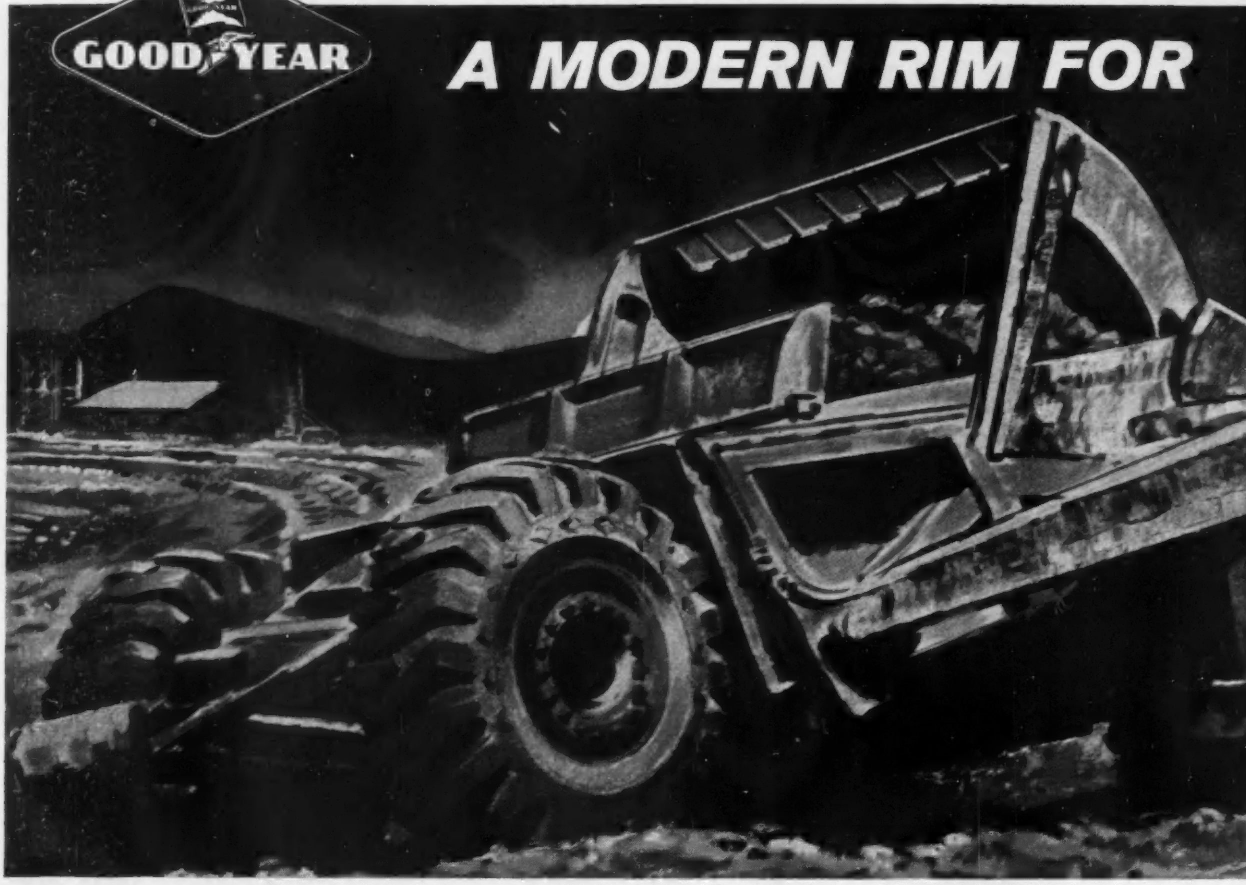

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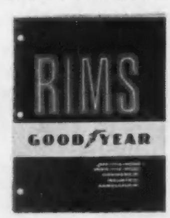

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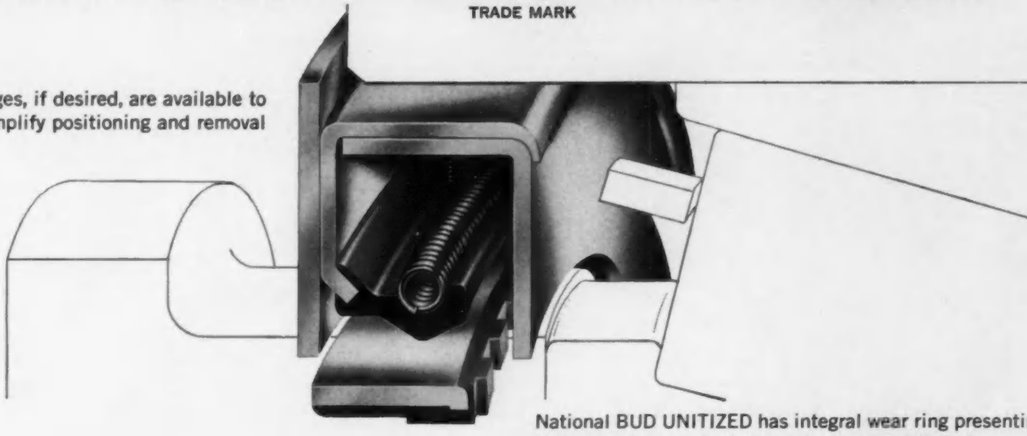

National BUD UNITIZED has integral wear ring presenting rubber surface to shaft. Wear ring turns with shaft, sealing lip is never exposed to damage, cannot score shaft.

A new unitized oil-seal-and-wear ring that eliminates:

SHAFT WEAR OR SCORING

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EXPENSIVE SHAFT FINISHES

COSTLY SHAFT RE-MACHINING

SEALING LIP INSTALLATION DAMAGE

SPECIAL INSTALLATION PROCEDURES

New National BUD UNITIZED seals are now in production, in a limited range of sizes, for heavy oil and grease sealing applications — including truck, bus and tractor uses. Still newer BUD UNITIZED seals are on the way for higher speed automotive and similar uses.

Changing a National BUD UNITIZED oil seal automatically changes the wear sleeve — in one fast, simple operation. Since the seal has its own integral wear ring, it is almost impossible to install it other than squarely on the shaft. Expensive shaft finishing is no longer a necessity, nor is leakage under a metal wear ring a problem — both thanks to the rubber surface BUD UNITIZED presents to the shaft.

For complete details or skilled engineering help on application of BUD UNITIZED seals, write direct, or call your National Seal Applications Engineer. You'll find him in the Yellow Pages, under Oil Seals.

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6013-R

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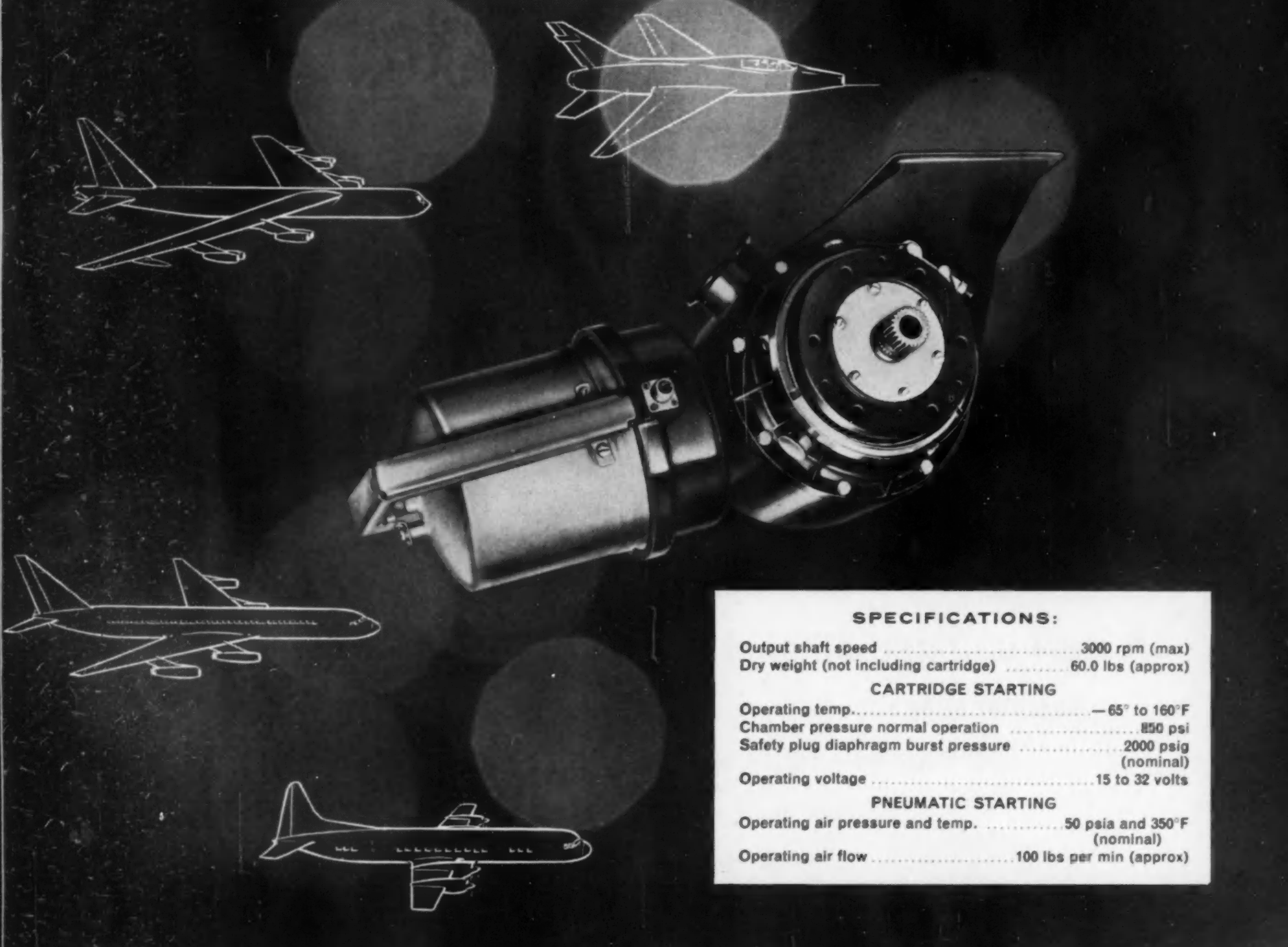

SPECIFICATIONS:

Output shaft speed	3000 rpm (max)
Dry weight (not including cartridge)	60.0 lbs (approx)
CARTRIDGE STARTING	
Operating temp.	—65° to 160°F
Chamber pressure normal operation	850 psi
Safety plug diaphragm burst pressure	2000 psig (nominal)
Operating voltage	15 to 32 volts
PNEUMATIC STARTING	
Operating air pressure and temp.	50 psia and 350°F (nominal)
Operating air flow	100 lbs per min (approx)

AIRESEARCH'S CARTRIDGE/PNEUMATIC STARTER *has completed more than 20,000 successful cartridge starts for the F-100, F-105 and Hound Dog missile applications.*

Completely fail-safe, this lightweight package is the only cartridge starter capable of full containment of a wheel hub burst.

The AiResearch starter is extremely flexible and compact, making it easily adapted to any jet engine envelope. For example, the same starter now used on the Hound Dog missile can be delivered immediately for use on the B-52 itself.

This self-contained, aircraft-installed starting system provides quick, dependable starts in any climate or location by means of high temperature cartridge gases *or* low pressure air such as supplied by an AiResearch gas turbine serving as an onboard pneumatic power source or conventional ground support unit.

The starter consists, basically, of an air turbine starter and a removable solid propellant cartridge chamber. Combustion of the cartridge directs high pressure gas against the turbine wheel, turning the output shaft. Overspeed is controlled by aerodynamic braking action of air compressed by radial blades on the other side of the turbine wheel.

This simple system consists of proven components with many thousands of hours of successful operating history. The pioneer and leading manufacturer of air turbine starters of all types for both military and commercial application, AiResearch has more than four years of cartridge experience and 12 years' experience in pneumatic starters.

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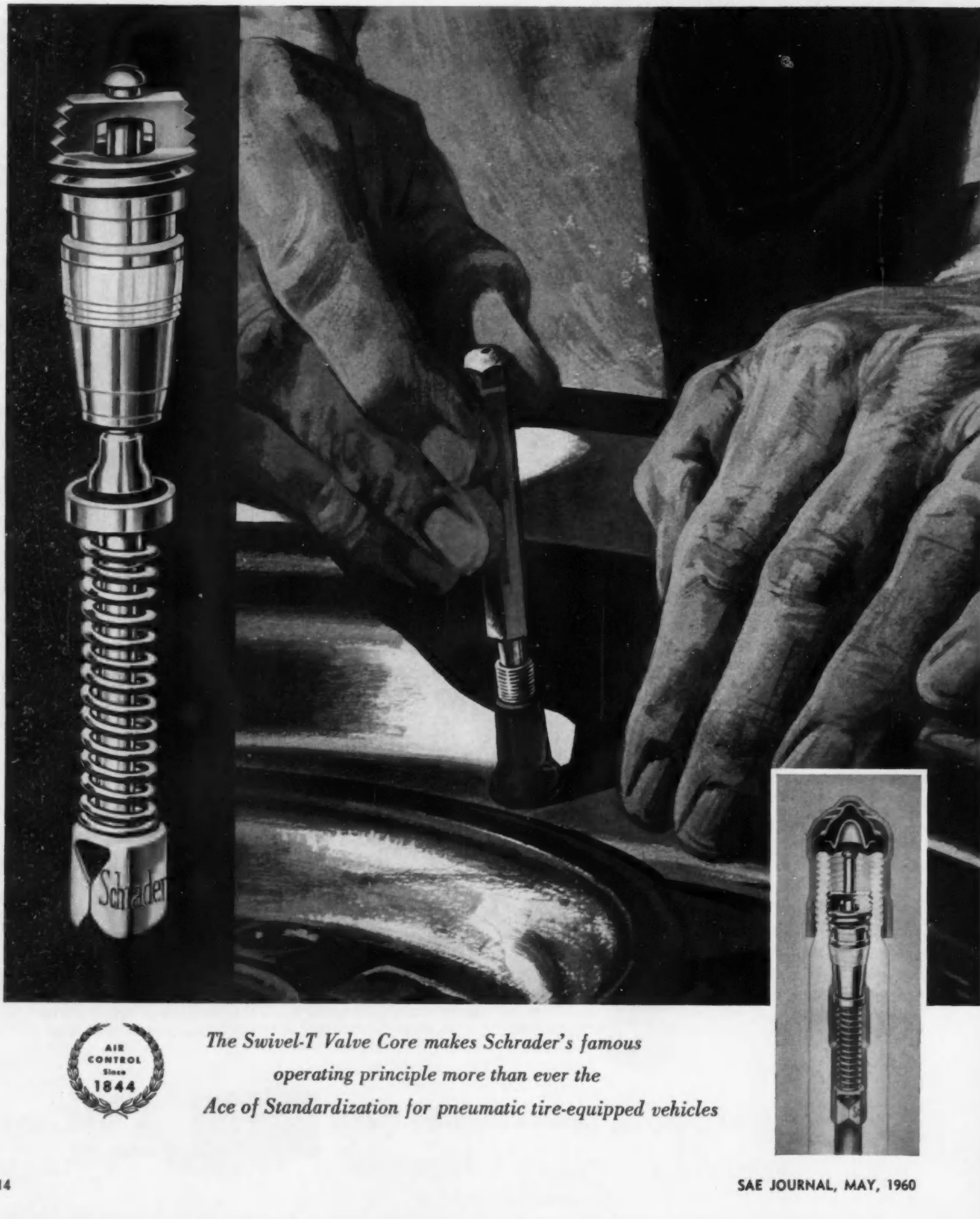

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The Swivel-T Valve Core makes Schrader's famous operating principle more than ever the Ace of Standardization for pneumatic tire-equipped vehicles

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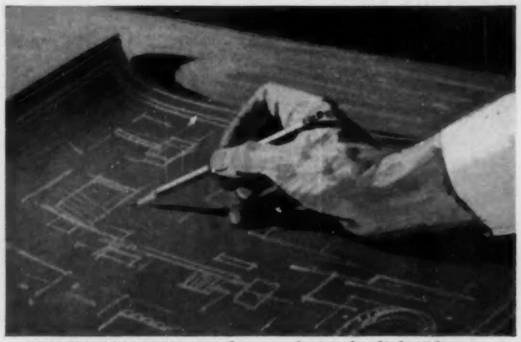
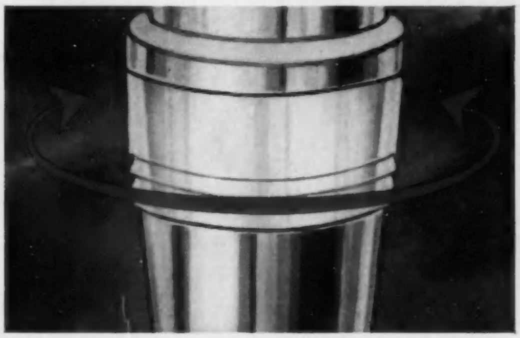
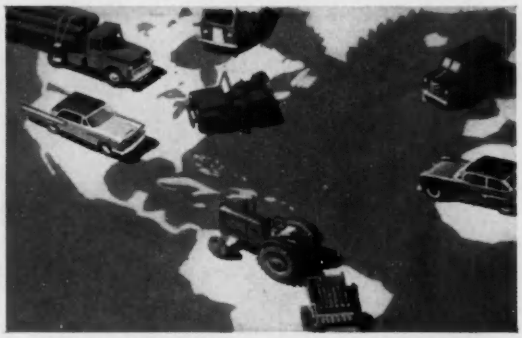
THE SEARCH for ways to improve Schrader products never stops. Even the smallest details of each part are constantly and exhaustively examined.



DESIGN CHANGES are often made in the light of new materials with new properties which have been created in the world's technical laboratories.



ENGINEERING CREATIVITY produced a new valve core design with six new performance benefits. Teflon with its super-slippery characteristics helped make this possible.



SWIVEL-T VALVE CORES have already travelled with all kinds of vehicles in varying terrains, proving themselves to be the most dependable valves ever.

The Automotive Industries are quick to take advantage of new scientific discoveries. Pooling ideas, skills, and knowledge, engineers in many companies from the Automotive, Tire, and Tire Valve Industries cooperate to improve even the smallest details. One recent example is Schrader's Swivel-T Valve Core, which employs precisely-machined Teflon in the plug washer to prevent cores from sticking and to make a more positive air seal. This advancement is one of countless benefits which have resulted from cooperative effort . . . another contribution which helps make vehicles even more dependable no matter where they go.

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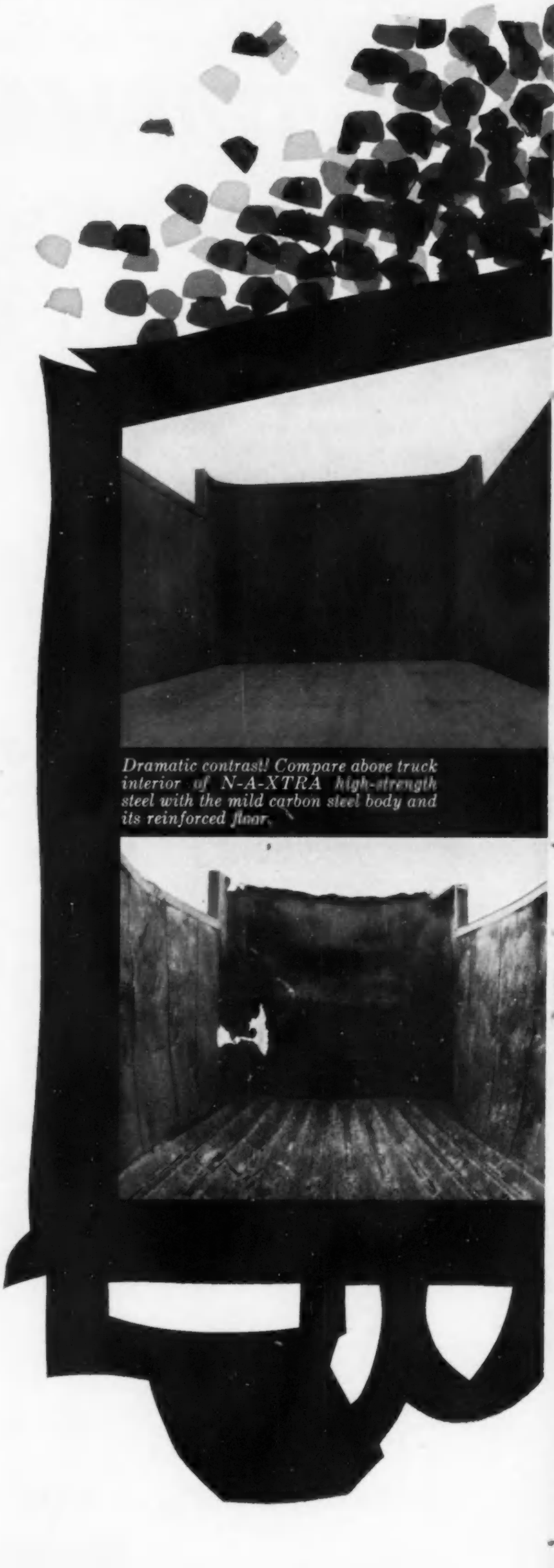
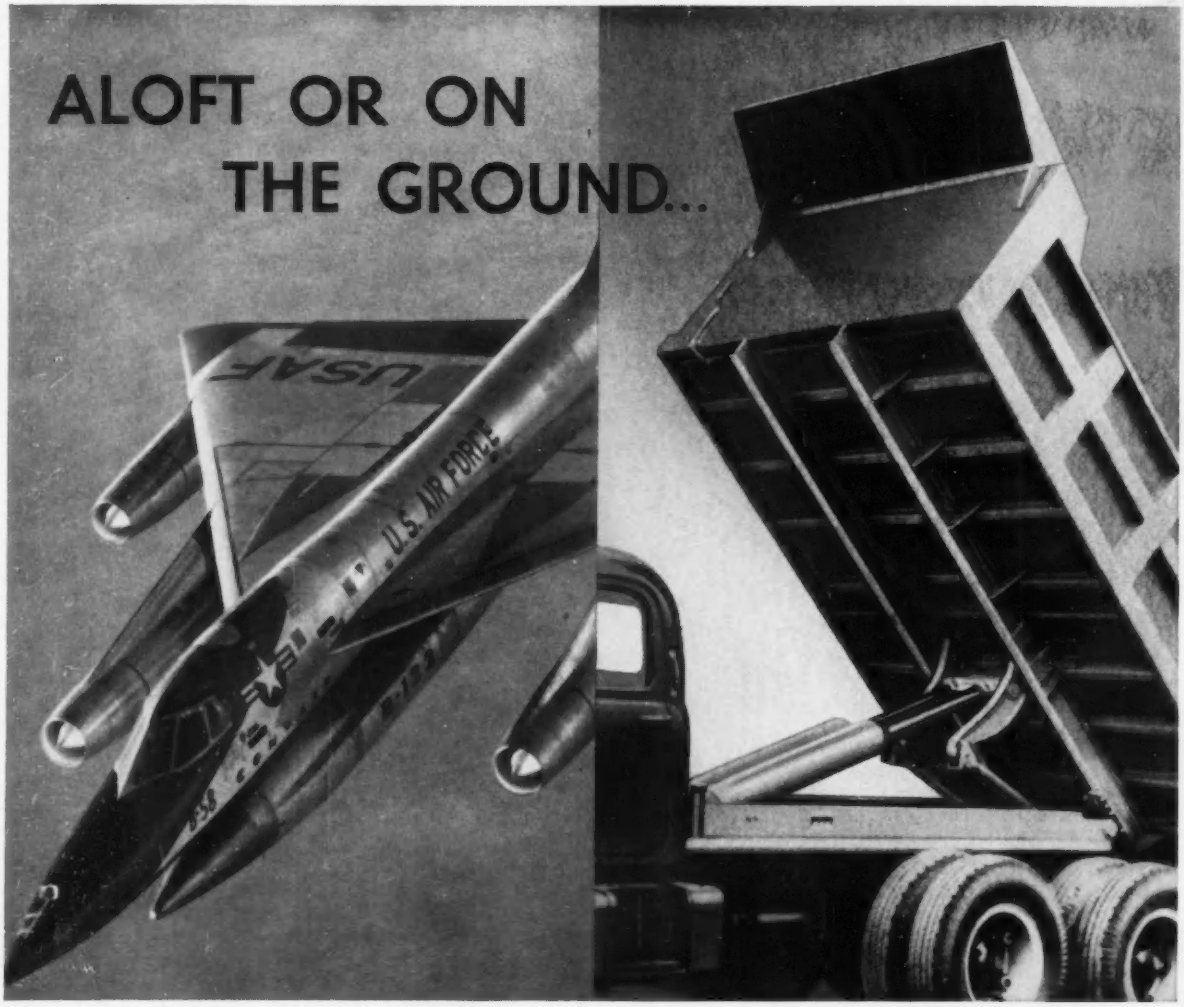


Dramatic contrast! Compare above truck interior of N-A-XTRA high-strength steel with the mild carbon steel body and its reinforced floor.



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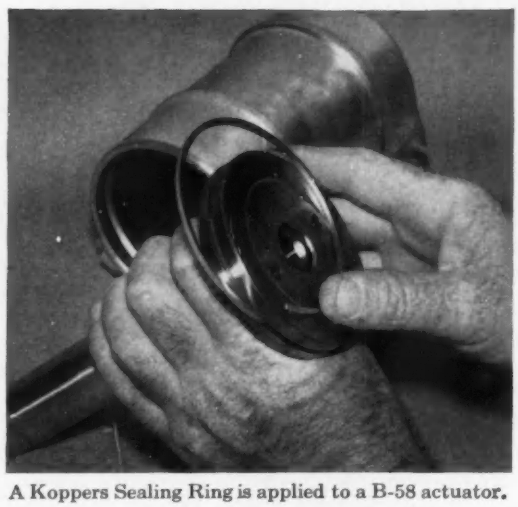

A Koppers Sealing Ring is applied to a B-58 actuator.

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SAE JOURNAL

For Sake of Argument

Faith . . .

AN ACT OF FAITH is involved in every decision we make. We decide to take a bus to work, on the basis of faith that the buses will be running. We order a meal — in the faith that we will get what we order. We have faith enough in a design we have conceived to put it on paper . . . and others have enough faith in it to authorize working models. Without faith, no decision can ever be made; no action taken.

In this sense, faith is substance . . . "the substance of things hoped for." It plays a more substantial part in business and engineering achievement than any other single element. Without it, the will and the way may not be found to acquirement of necessary skills and knowledge. Without its call to action, even already-acquired skills may atrophy.

Faith is the result of sound reasoning, not reason's antithesis. Material fact is a less sound basis for action than what Rufus Jones calls "the majesty of the categorical imperative — 'thou canst because thou ought.' "

Too often we think of faith as "blind faith"; echo the Sunday School boy's definition: "Faith is believing in what you know isn't so."

This is a long way from Santayana's "invincible surmise" through which:

> "Columbus found a world, and had no chart,
> Save that one faith deciphered in the skies;
> To trust the soul's invincible surmise
> Was all his science and his only art."

The power of faith in our individual lives varies, of course, with what we have faith in.

Norman G. Shidle

chips

from SAE meetings, members, and committees

10-50% OF THE COST of manufacturing aircraft and missiles is in the cost of testing and test equipment.

BERYLLIUM DEVELOPMENTAL EXTRUSION BILLETS cost more than one hundred dollars per pound — when the high cost of processing is added to the high basic price.

TODAY THERE ARE OVER 5000 INDUSTRIAL LABORATORIES in the United States, as compared with only 290 in 1920.

MANNED SPACE TRAVEL will require more knowledge from instrumented vehicles and flight studies on animals. Current knowledge indicates that some form of shielding will be required. A possible problem is that moderate shielding for the Van Allen radiation belt will slow up high energy cosmic particle radiation to the point where long-term exposure in space may be more dangerous than with no shielding at all. It may be that only very thin (the equivalent of 0.15 in. of lead) or very thick shields (greater than 6 in. of lead) can be used.

STANDARD AMERICAN PASSENGER CARS contain about 150 lb of polymers. About 100 lb go for the tires.

ABSOLUTE AND UNVARYING RELIABILITY is one of the most fundamental, but least appreciated, aspects of radioactive decay. The rate of decay of a certain species of radioactive material has been found to be free of any external influence that has, thus far, been imagined in the scientific realm. Our data are now so complete that, given a certain radioactive isotope, we can predict, with utmost confidence, what the emission level will be one hour, one day, one year, or a hundred years hence.

QUALITY CONTROL — S. E. Knudsen, GM vice-president and general manager of Pontiac Motor Division, maintains a close surveillance on quality by driving home a newly assembled car daily.

OF SOME 179 FLIGHT PERSONNEL TRAINED FOR JET AIRCRAFT by United Air Lines, only eight individuals have dropped out of the training program for physical or other reasons.

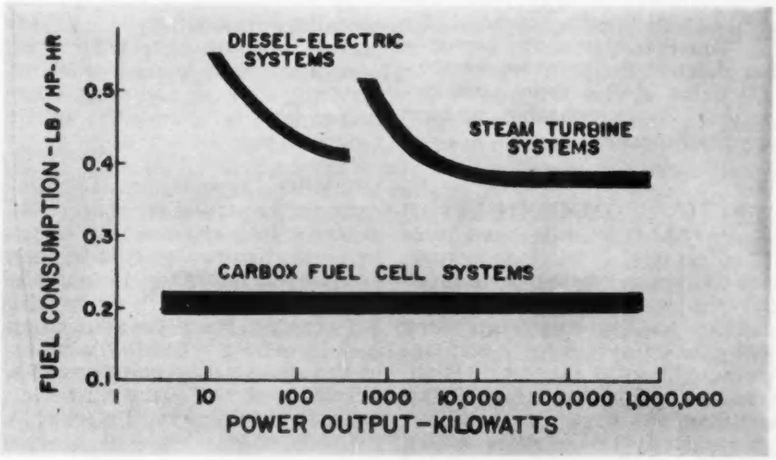
LIGHT COLOR OR REFLECTIVE-TYPE PAINT shows a definite benefit over darker paints in the hot areas of this country. In-car temperatures of cars parked in the sun showed up to 15 deg cooler after a one-hour soak period in the car having the light colored paint. Once the cars are in motion, roof metal temperatures show only a 2–3 F difference between white and black paint, offering no measurable advantage.

SHEET STEEL, ONLY 0.006 IN. THICK, will cover much of the B-70. This is not as ridiculous as it seems — since 0.001 in. extra in skin thickness will increase the B-70's weight by one ton.

1000 POUNDS have been saved in the B-70 hydraulic system — by replacing threaded couplings with brazed tubing fittings.

(more chips on following page)

FUEL CONSUMPTION in a fuel cell system should be independent of power output, as evidenced by the comparison (shown in the chart below) of efficiencies of systems using hydrocarbon fuels.



chips

from SAE meetings, members, and committees

MODERN MISSILES may have upwards of 2500 test check points and 5 million circuit combinations. Thus only one error in one million still results in five bad connections.

NEW WORD, NEW INSTRUMENT — The word "ovality" has been coined to express the variations in diameter of an object which has no center. A new instrument has been developed to measure it. It will automatically record the variations in the diameter of a rim, both at the flange and gutter. It's an ovality gage.

SOME USAF AIRCRAFT require as much as 10 man-hours per flight hour to repair acoustically-induced fatigue damage. The accumulative cost of repairing this damage since 1955 is about $63,000,000 for aircraft now in service. These figures were pointed out recently at the First International Conference on Acoustical Fatigue.

RELIABILITY OF ROCKET ENGINES — such as used for emergency standby power — has reached the point where 100,000 units of one type have, reportedly, been operated without any malfunction.

INITIAL COMMUNICATION SATELLITES will have little effect on U. S. telephone trunkline business. Possible early satellite microwave communication capability will be small compared with the current largely civilian, transcontinental capacity. If we compare microwave relay links, simultaneous voice conversations transmitted on earth (AT&T trunklines) are 14,400 as compared to 1000 for a 24-hr satellite (oriented). Carried on earth are 24 alternate TV channels; two could be carried by a satellite. On earth, power per voice channel per relay is 0.003 w, and total power required equals 40 w. The satellite would require 6 w per voice channel, and a total of 6 kw.

GAS BEARINGS have attained speeds of over 100,000 rpm, which makes them attractive for accessory power units, according to a Boeing research engineer. He reports that possible temperature requirements are now up to 1200 F and turbine speeds are approaching 100,000 rpm, and more.

IN 1959, FOR THE FIRST TIME IN HISTORY, the United States imported more cars than it exported . . . and the gap is expected to increase this year.

Space-Age Dictionary

inherent reliability — designed-in reliability.

secondary reliability — those aspects of reliability affected by shop personnel, inspectors, truckers, servicing workers, and every other person who influences the article before its use.

reliability apportionment — allocation of minimum reliability percentages to components of a system and then to elements in each component, based on the reliability figure for the whole system. For example, if a hydraulic system is to have 95% reliability, a pump in the system may be allocated a reliability of 99.9% and an o-ring in that pump may need a reliability of 99.9994%.

THE TECHNICAL AXIOM THAT NOTHING IS IMPOSSIBLE sinisterly conditions one to the pitfall corollary that nothing is ridiculous.

90% OF THE AIRCRAFT AND MISSILES INDUSTRY uses automatic test equipment. 84% of these companies use automatic testing for other than just continuity checking. This is in sharp contrast to a survey made of the industry just two years ago and indicates a marked increase in the use of automatic test equipment.

THE AVERAGE PERSON produces about 10,000 Btu per day of heat energy that is given off to the surrounding atmosphere. This amount of heat is sufficient to raise 6½ gal of water from freezing to the boiling point. The heat is created internally by the slow combustion of food stuffs, energy expended to maintain life processes, and muscular activities. The body loses heat by radiation, convection, and evaporation.

PROVED RESOURCES OF FISSIONABLE MATERIAL exceed by 10 times the energy content of the equivalent resources of all fossil fuels, including natural gas, oil, and coal.

EXCESSIVE LAP where the ends of threads are brought together in the making of a tire will cause a hot spot in service, leading to blowouts and tread separation. Thermocouples prove that the tread temperature at this thread splice point can run 25 deg hotter than at any other place on a tire's circumference.

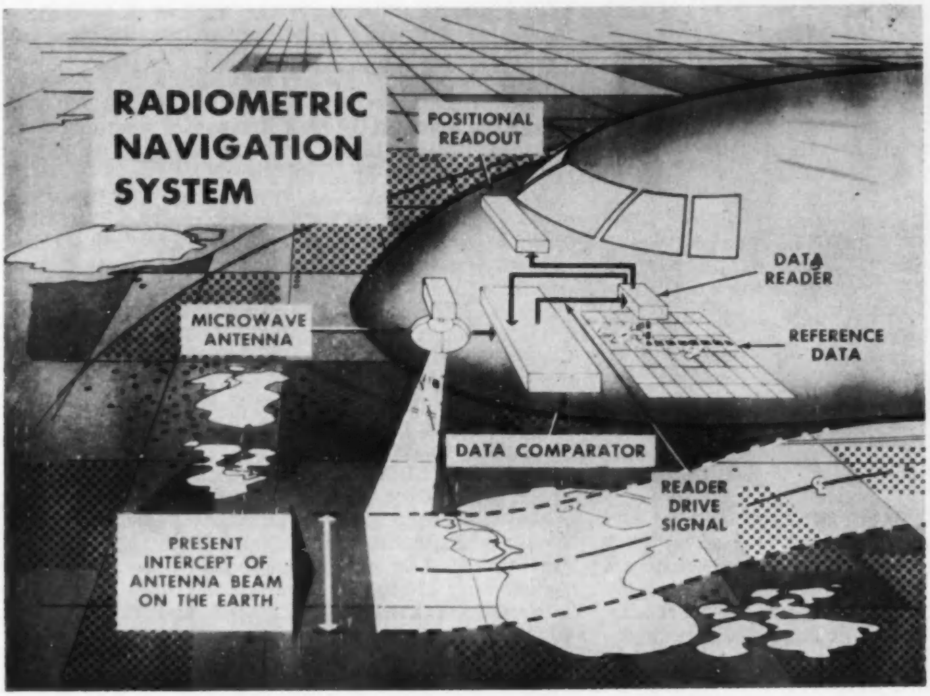


Fig. 1 — This proposed map-matcher is an example of a currently practical application of space-age research and development. This device would identify the position and path of an aircraft passing over a given location . . . and would also indicate in the aircraft its precise location at any time.

Today's Engineering Can Use Space Age Gains

▸Research and development exploding from awareness that space is an accessible frontier can have immediate potentials.

Based on paper by

H. C. Zeisloft

AC Spark Plug Division, CMC

BEING on, in, or a part of today's exploding technology is impelling engineers in every automotive area to exert themselves as never before. . . . They are trying sincerely to do better in terms of their own understanding. In many automotive areas this means culling from the ever-growing body of space-age research ways to improve our ability to produce more, more economically, with a given amount of mechanical energy.

To do this, a degree of technical alertness is required greater than ever before conceived. Technical progress is currently an exploding force which defies definition. . . . And in scores of these space-age areas, researches have been developing much data of significance to engineers in every phase of the automotive industries.

SYNTHETIC MATERIALS, for example, have continued to expand tremendously. Military demands have hastened such developments as teflon — in the many forms and configurations which take advantage of its electrical and frictional properties. (One form, known as DU material, consists of a very thin layer of porous bronze impregnated with a combination of lead and teflon.)

Many new resins, developed for specific purposes, have molecular structures aligned to suit particular requirements. These include many types of polyesters and epoxies which are finding use in the adhesive field, in laminating, in casting, and in the develop-

ment of thin, tough films. (Mylar is a good example of a thin, tough film.)

THE FIELD OF ADHESIVES itself has been extended — by basic research into the nature of adhesion — to cover a wide range of compatible materials. Aircraft now flying are using structural metal elements which are glued together. Missiles and space ships use metallic honeycomb panels with metal faces bonded to each side.

NEW METALS are being widely exploited. Titanium, lithium, and beryllium stand out as representing major accomplishments. *Titanium* is now being fabricated for missile structures, and a wide background of experience is available for its further use. *Lithium* has been used as a catalyst in synthetic rubber production . . . and ways are being found to machine *beryllium* so that its superior physical characteristics can be utilized.

Nickel oxide batteries and silver-zinc batteries — originally developed for missile work — represent potential advances in the design of civilian equipment needing lightweight and small batteries.

THROUGH NUCLEAR PHYSICS developments, radioisotopes have become a useful part of industry . . . and even the transmutation of metals is now a reality. The electronics field has also grown very rapidly. Semiconductors, transistors, tunnel diodes, and similar devices make up a large field in themselves. Micromodular structure of electrical components has been developed to permit hundreds of elemental electronic functions to be built into packages with dimensions in fractions of inches. Complete radio receivers, for instance, which meet Air Force requirements, have been built into packages the size of an ordinary sugar-cube. The so-called tinker-toy method of manufacture is expected to further reduce the cost of electrical equipment via completely automatic manufacture and assembly.

INFRARED RADIATION advances have brought new types of sensing elements and inspection devices. Heat-seeking missiles, involving infrared sensitive elements, now can search out and home upon very, very small heat sources. So, these sensing elements are currently being used in air-to-air missles.

COMPUTERS continue to record fascinating advances. Advances in magnetics have provided computers with many new capabilities, particularly with regard to memory elements. Computers using these advanced concepts accept quantities of factual information and react according to prescribed laws of logic to provide logical answers to new problems fed to them. For instance, a checker-playing machine stores its experience in each game and refines its techniques so that it becomes more and more difficult to defeat.

Eventually, computing systems will accept problem statements, or even sketches, describing what is to be done . . . and the computer will figure out how to do it. Instead of an operator analyzing the problem and programming it for the computer system, the system itself will be capable of analyzing, programming, computing, and presenting the results in the desired form. The results may be presented as printed read-outs, charts, drawings, or even machined parts from a machining element. Already, of course, computers can solve equations involving thousands of calculations in a matter of seconds.

ROBOTS of various types have been developed for work in radioactive areas. Such robots are being used for intricate and precise handwork as well as for heavy materials handling. A mobile robot at Hughes Aircraft has closed-circuit TV eyes, hydraulic muscles, handling arms capable of lifting 150 lb and a lift platform with a 1500-lb capacity. It has a vertical reach of 10 ft, a horizontal reach of 3 ft. It is controlled through a long cable. The entire robot weighs 4500 lb.

At Republic Aircraft, a "spark-bomb" device forms metals which are very difficult to work. Electrical power is stored by capacitors and released in 40 millionths of a second. The discharge takes place under water and develops a high-velocity shock wave which is directed toward the material to be worked. Several thousand horsepower have been developed in this almost direct conversion of electrical energy to mechanical power.

Gyro-stabilized platforms now exist which are less than 1 cu ft in volume, less than 30 lb in weight, and have a life in excess of 1000 hr.

NEW POWERPLANTS include stationary atomic power generation stations, turbines for small aircraft, and other types of auxiliary powerplants for use on missiles and space ships. One new small aircraft turbine is on its way, for example, which weighs only 110 lb, yet develops 250 hp.

SONIC WELDING OF ALUMINUM is a recent development. It is being accomplished with equipment commercially available now.

NEW TYPES OF GLASS-LIKE MATERIALS are now solving some of the problems of low-friction, very-high-temperature bearings. A crystalline ceramic has been developed which gives a transparency to 90% of light, and is stable at 3600 F. Other new skills acquired in the field of glassmaking have resulted in a glass useful at very high temperatures in aircraft.

Thermoelectric devices which directly convert electrical energy to heat or cold promise many new applications in the automotive, as well as in other industries.

Converse equipment has been made, which directly converts heat into electrical energy. Familiar by now is the tractor, operating on power cells, which incorporates a similar principle of direct energy conversion.

Proposed now by AC Spark Plug is a map-matcher which would scan the earth, and — in conjunction with a map — identify the position and path of an aircraft passing over. It would also indicate in the aircraft its precise location at any time. This device can be assembled with today's techniques and knowledge. Fig. 1 shows the location of the various components of the map-matcher. Examination of this proposed map-matcher will generate in the minds of many engineers additional, similar potentialities.

Scores of other potentially applicable new developments are coming from space-age researches every year. From recent military researches may well come improved rocket take-off boosters for supersonic commercial airliners; missile-type vehicles for mail and freight service; TV relay satellites; telephone exchange satellites; weather satellites; and many more. The possibilities have only begun to come into focus for engineers.

To Order Paper No. 112A . . .
. . . on which this article is based, turn to page 6.

Computer Designed Engine Mounts Control Car Shake

Fig. 1 — Test setup for measuring engine mode shape data.

Based on paper by

Earle Stepp

Chrysler Corp.

COMPUTERS ARE DESIGNING ENGINE MOUNTS to control passenger-car shake. After a mathematical model of the physical system has been set up with all mathematical operations defined and the form of solution specified, the problem is turned over to the computing laboratory for programming, coding, and checkout. Upon completion of these steps, computation can start with evaluation of results following shortly.

The first step in designing a mounting system to control shake is to determine the engine frequency and mode shape required to match the structural deflections at the engine mounting pads. This is done by taking measurements at the engine mounting pads (Fig. 1). Forces are applied at the tire centerline by 200 lb electromagnetic shakers over a frequency range of 6–20 cps. The tests are conducted with the engine supported from the floor. Two soft coil springs prevent the front of the car from rising when the weight of the engine is removed. Vibration transducers attached to engine mounting pads on the car structure measure the response curves at each pad. Measurements are made for front and rear wheel hop and tramp excitation.

A typical response curve at a front engine mounting pad for front wheel hop excitation is shown in Fig. 2. Here, the critical frequency of 12½ cps is selected for measurement of mode shape. The mode shape is determined by measuring the complex deflection (amplitude and phase angle) at 12½ cps for each mounting pad.

The next step is to calculate the deflections of the engine center of mass required to produce the deflections which were measured at each mounting pad. The general relationship between deflections at the engine c.g. and an engine mounting location is shown in Fig. 3. For a typical passenger-car mounting system with 3 mounting locations, a total of 9 translational deflections are measured. Assuming that none of the deflections in the same direction are equal, all 9 translational deflections must be satisfied by one set of 6 deflections in the engine c.g. Obviously a unique solution is not always possible.

Special techniques must be used and compromises must be made for cases where equal mounting pad deflections are prevented by coupling of structural twist and bending. The typical case for a passenger car, however, usually reduces to a relatively direct solution. This is due to lack of coupling between lower structural modes and the location of principal inertia axes of the engine mass. For pure structural bending, the deflections at the right front mounting pad are equal to deflections at the left front mounting pad. For pure structural twist, these deflections are equal and opposite.

The location of engine principal inertia axes controls dynamic coupling between rotational coordinates. The engine can rotate about any principal inertia axis without producing a moment about any other axis. The principal inertia axis which runs laterally through a conventional engine is almost normal to a vertical plane containing the crankshaft centerline. Because of this, the engine can pitch

Computer-Designed Engine Mounts

. . . continued

without causing yaw or roll motions due to mass coupling. (Engine pitch, yaw, and roll here are defined as rotation about a lateral axis, rotation about a vertical axis, and rotation about a fore-and-aft axis respectively).

Deflections at the front mounting pads are identical for pure structural bending and lateral, yaw, and roll deflections at all mounting pads are zero. This leaves a total of 4 different translational deflections at the mounting locations and 3 unknown deflections at the engine c.g. Substitution of the 4 mounting pad deflections into equations (Fig. 3) yields four equations.

Since there are only three unknowns, a unique solution for the required engine mode shape cannot be made. For this particular case, however, vertical and pitch deflection are of primary importance and two of the four equations are used to solve directly for them. The two remaining equations provide two different values for the fore-and-aft deflection. These two values are averaged to obtain a figure to complete the engine mode shape.

Another and possibly better way to determine a value is to use the criterion that the sum of all the forces transmitted to the structure in the fore-and-aft direction shall be zero. The sum of these forces provides one equation involving mounting rates and deflections at the engine c.g. This equation can be solved uniquely for X, the fore-and-aft deflection at the engine c.g. We now have six deflections which completely describe the engine mode shape required to dynamically fit the engine to the structure-suspension assembly for front wheel hop excitation.

One additional factor, the frequency for this mode, must be determined in order to achieve correct phasing of engine and structural oscillations. Don Hartog[1] derived the relationship $f = \frac{1}{1 + M_2/M_1}$ for optimum tuning for a two degree of freedom system. Since the engine mass is large, this relationship indicates that we can expect an engine frequency appreciably lower than 12.5 cps to provide optimum tuning for this system. The precise tuning frequency cannot be calculated readily because of the difficulty in determining the mass of the structure involved. Empirically the engine frequency has been found to vary from 0.8 to 0.9 times the main mass frequency. A good estimate of the engine frequency required for this specific application is the average of 0.85 times the peak frequency in Fig. 2 which is 10.6 cps. A complete description of the engine mode required for an effective dynamic absorber for this application is:

Frequency f – cps	Fore & Aft X	Vertical Y	Lateral Z	Roll Θ	Yaw Φ	Pitch Ψ
10.6	0.198	1.0	0	0	0	−0.073

The numbers listed for X, Y, and Ψ were calculated

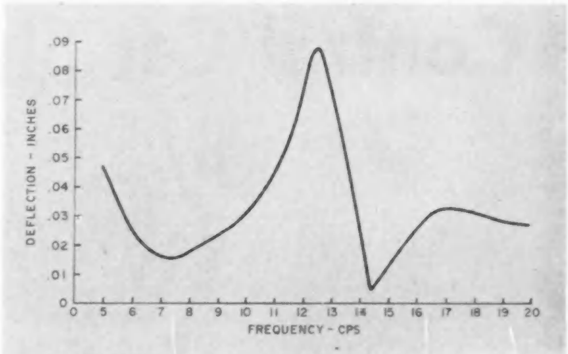


Fig. 2 — Left front engine mounting pad response; front wheel hop input equals 150 lb at each wheel.

[1] J. P. Den Hartog, "Mechanical Vibrations."

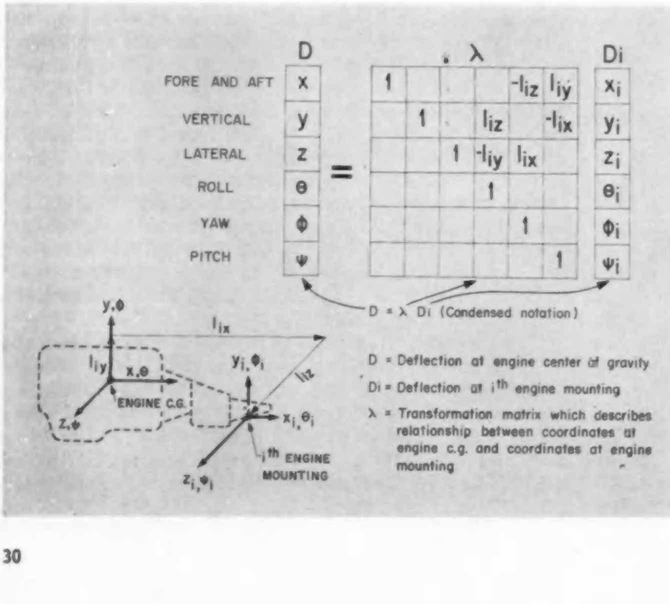


Fig. 3 — Engine center of mass deflections expressed in deflections at *i*th engine mounting location.

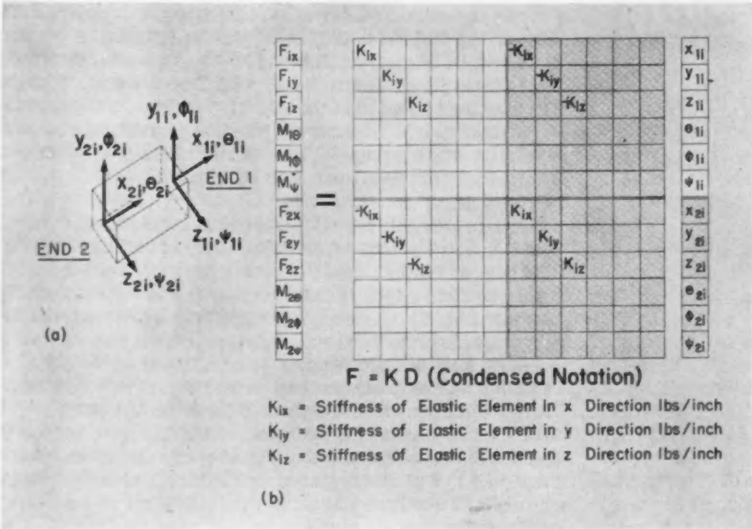


Fig. 4 — (a) Principal coordinates for *i*th elastic element. (b) Stiffness matrix relating forces and deflections at end 1 and end 2 of *i*th elastic element (shaded portions vanish for the boundary conditions that deflections at end 2 are zero).

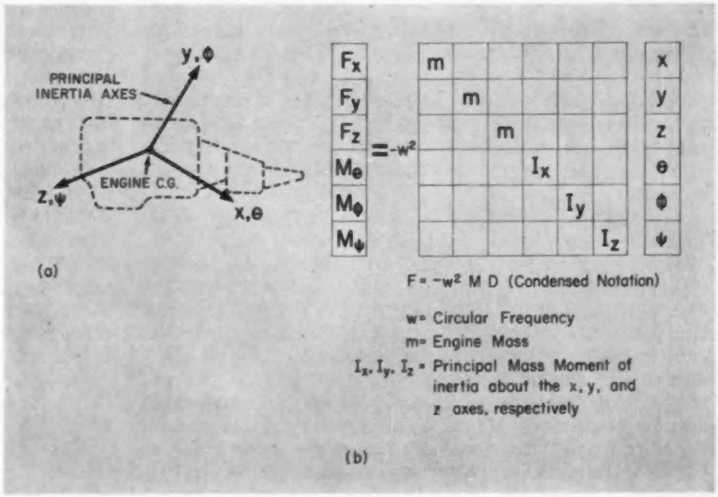


Fig. 5 — (a) Principal inertia coordinates. (b) Mass matrix in principal coordinates.

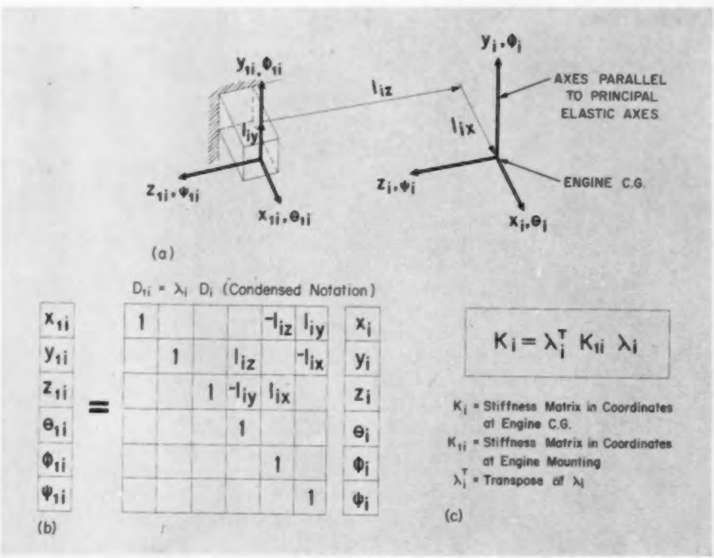


Fig. 6 — (a) Location of the *i*th engine mounting with respect to engine c.g. (b) Coordinates at engine mount expressed in parallel coordinates at engine c.g. (c) Mathematical operations for coordinate translation transformation.

Computer-Designed Engine Mounts

. . . continued

as described earlier and then normalized by dividing each number by the largest number.

The final step is to determine by computer analysis an engine mounting system which will have a mode that matches the mode shown above. The ideal method of solution would be to solve directly for mounting rates and locations from input data of the six frequencies and six mode shapes. This form of solution can be made only for a few special cases which are of little value for a practical problem. The mode shapes and frequencies can be found from input data of engine mass properties, mounting locations, mounting rates, and orientation of principal elastic axes for each mounting. Solutions or mode shapes and frequencies can be computed for many mounting locations and any combination thereof. In this manner mounting rates and locations can be determined which approximate the required mode to control shake.

The problem can be formulated mathematically in a methodical fool-proof manner by analyzing each element individually and then performing coordinate transformations to assemble the composite system.

An engine mounting is illustrated in Fig. 4(a). This element is analyzed in the most convenient coordinate system which is the principle elastic coordinate system shown at end 1 and 2 of the mounting. Fig. 4(b) shows the stiffness matrix for this primitive element. The stiffness matrix describes the relationship between forces and deflections at each end of the elastic element. With an engine mounting, rotary resistance and coupling of coordinates can be neglected. Thus, an adequate mathematical description of the mounting can be derived from three orthogonal translational rates as shown in Fig. 4. Boundary conditions can be applied either in the primitive system or in the composite system, whichever is more convenient for the specific application. The cross-hatched portion for the primitive elastic element in Fig. 4 vanishes for the boundary condition that all deflections at end 2 are zero. In the remainder of the matrix the first 6 rows mathematically describe the forces applied to the engine at end 1 of the mounting. The last 6 rows describe the boundary forces which are applied at end 2 of the mounting.

The principal inertia coordinates and the mass matrix for the mass element are shown in Fig. 5. The mass matrix is expressed in principal coordinates so that products of inertia do not appear. This matrix can be derived by applying an acceleration along each coordinate and summing forces.

Mass and elastic elements are the only basic elements involved. Damping elements have been neglected because of the minor effect on the frequency and mode shape and because of the much increased machine time required to solve the problem with damping. For more than one elastic element each element is analyzed as previously described and then summed to form a composite stiffness matrix for the complete mounting system. Prior to summing, however, all stiffness matrices must be transformed to a common coordinate system. It is convenient to choose the engine principal inertia coordinates as this common coordinate system. To express the stiffness matrix in principal inertia coordinates a translation transformation must be performed.

Mechanics of the translation transformation are shown in Fig. 6. Part (a) gives the geometrical relationship of the engine mounting and engine c.g. The relationship between coordinates at the engine mounting and parallel coordinates at the engine c.g. is given in part (b). The same mathematical relationship is also given in condensed notation where one letter or symbol represents a matrix. The 6 by 6 matrix shown in part (b) is represented by the symbol λ_i. Mathematical operations for performing the translational transformation are shown in condensed notation in part (c) of Fig. 6.

The stiffness matrix for the *i*th mounting is now transformed to coordinates parallel to principal elastic coordinates with the origin at the engine c.g. The origin for the stiffness matrix now coincides

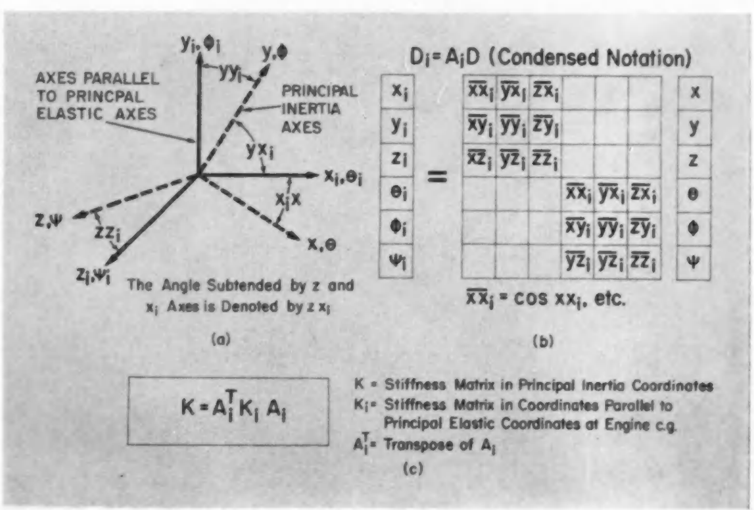


Fig. 7 — (a) Angular orientation of principal elastic coordinates at engine c.g. and principal inertia coordinates. (b) Principal elastic coordinates expressed in principal inertia coordinates. (c) Mathematical operations for coordinate rotation transformation.

with the origin for the principal inertia axes. The axes for the stiffness matrix must now be rotated until they also coincide with the principal inertia axes. The angular orientation of these two sets of axes are shown in part (a) of Fig. 7. Part (b) gives the mathematical relationship between the two sets of coordinates and part (c) shows the mathematical operations for the coordinate rotation transformation. The stiffness matrix for the ith mounting is now expressed in principal inertia coordinates. This same procedure is repeated until all mounting stiffness matrices are expressed in inertia coordinates. All stiffness matrices and the mass matrix are now in a common coordinate system and can be summed to form the characteristic equations for the engine mounting system. When these equations are written in condensed notation they are identical to the equation for a single degree of freedom system. Each symbol, however, represents a matrix instead of only one number. The equation is:

$$F = [-\omega^2 M + K_t]D \qquad (1)$$

where:

- F = External forces applied to the system
- ω = Circular frequency
- M = Mass matrix
- K_t = Sum of all mounting stiffness matrices
- D = Deflections along principal inertia axes

The solution of equation (1) for $F = 0$ and $D \neq 0$ provides all the normal frequencies and mode shapes for the engine. Note, however, that if this were for a single degree of freedom the frequency squared would equal K_t divided by M. The mode shapes are in inertia coordinates and are therefore difficult to interpret. To correct this condition one final transformation is performed to express the six mode shapes in coordinates parallel to car design axes. The frequencies are the same in any coordinate system and do not require a transformation.

The problem at this stage has been converted to a mathematical model of the physical system with all mathematical operations defined and the form of solution specified. At this point the problem is turned over to the Computing Laboratory for programming, coding and check out. Upon completion of these steps production computation can start with evaluation of results following shortly.

Production computation involves computing eigenvalue solutions for various mounting locations or rate combinations until the required mode is approximated. These problems are usually computed and analyzed in groups of ten to permit more intelligent adjustment of parameters in trying to achieve a desired mode. An empirically determined mode which was required to control shake for one vehicle is shown in Fig. 8 (b). The solution for a mounting system developed by production computation to approximate the required mode is shown in Fig. 8 (a). The first column merely identifies each mode with a number. The second column lists the eigenvalues (or natural frequencies) and the remaining columns describe the eigenvectors (or mode shapes). Each row completely describes one mode by giving the normal frequency and mode shape corresponding to that frequency. Mode one for example has a frequency of 15.3 cps and is composed of fore and aft (x), vertical (y), and Pitch (ψ) motions. Notice that mode 6 in this solution is a very good match for the

		FORE AND AFT	VERTICAL	LATERAL	ROLL	YAW	PITCH
MODE NO.	FREQUENCY cps	x	y	z	θ	φ	ψ
1	15.3	1.0	-.060	≈ 0	≈ 0	≈ 0	.041
2	9.65	-.32	1.0	≈ 0	≈ 0	≈ 0	.036
3	8.99	≈ 0	≈ 0	1.0	.051	-.010	≈ 0
4	16.4	≈ 0	≈ 0	-1.0	.433	-.106	≈ 0
5	12.8	≈ 0	≈ 0	-.727	.708	1.0	≈ 0
6	10.7	.873	1.0	≈ 0	≈ 0	≈ 0	-.077

(a)

FREQUENCY cps	x	y	z	θ	φ	ψ
10.6	.198	1.0	0	0	0	-.073

(b)

Fig. 8 — (a) Eigenvalues and eigenvectors for an engine mounting system. (b) Eigenvectors and eigenvalues required for a specific structure — suspension combination.

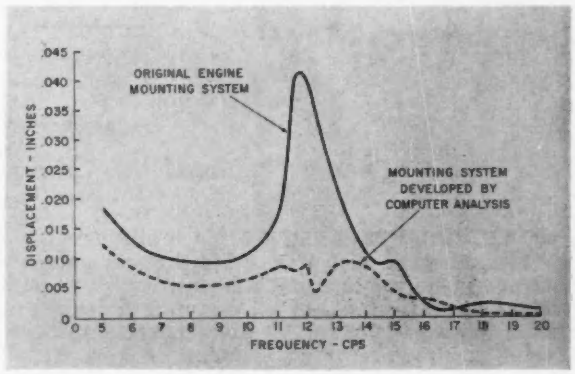


Fig. 9 — Complete car bending motion — front wheel hop excitation.

required mode. The match is especially good for frequency, vertical deflection, and pitch. This fit is sufficiently good to merit installation in a car for evaluation on the shake analyzer with minor modifications if necessary. The final system developed for one model is compared to the original system in Fig. 9. Note the large reduction in shake amplitudes achieved with the matched mounting system. These same results were confirmed by shake evaluation of the car on a rough road.

Thus, one engine mode can be tailored to control a bending mode of shake. This same process can be used to match more than one mode to a structure. For example, a structural twist and a structural bending mode can be controlled by fitting one engine mode to each structural mode. This process is not theoretically limited to two modes. When the number of modes used exceeds two, however, the problem of controlling engine frequencies and mode shapes simultaneously becomes very difficult. From a practical standpoint and at this stage of the art, the number of modes which can be used efficiently is two. In almost all applications, however, two engine modes are sufficient to develop a vehicle with excellent shake properties.

To Order Paper No. 127B . . .
. . . on which this article is based, turn to page 6.

Single reactor all-nuclear favored for nuclear

Flight reliability and optimum design can design, according to preliminary assessment

Based on paper by

Lionel W. Credit

Martin Co.

OF THREE ALTERNATIVES for achieving flight reliability in nuclear aircraft through component or system redundancy, the single-reactor, all-nuclear aircraft seems to be the optimum design. Martin engineers came to this conclusion after making a preliminary assessment of how these alternatives (the other two are dual-reactor and nuclear-chemical systems) affect design — particularly weight and growth potential.

They also investigated what the component reliability requirements would be for each system. An adequate flight reliability goal was considered to be flight safety equivalent to that of a four-engine chemical aircraft.

The all-nuclear, single-reactor system was thought best because not only would this result in the lightest aircraft with the best growth potential—but by leaving out the many components required to provide chemical power, maintenance would be reduced and flight utilization enhanced. The reactor and certain parts of the primary loop would be unduplicated and consequently require very high unit reliability . . . but these can be considered mechanically relatively simple compared to a chemical engine unit. However, it was recognized that it would be some time before enough is known about nuclear powerplant components to assess the reasonableness of this approach.

The dual-reactor system showed size and cost disadvantages, which made it look like an unlikely solution to the problem.

The third alternative — nuclear-chemical aircraft — will probably be the first type of nuclear aircraft developed. However, the problems of an aircraft designed with the required emergency chemical cruise range include not only design penalties but also additional maintenance requirements.

LIONEL CREDIT spent 20 years in Aircraft Maintenance Engineering with the Navy before joining Martin.

Three of his four years with Martin have been concerned with nuclear propulsion application studies . . . where he has been establishing flight vehicle operational practicability, military worth and general requirements of weapon systems.

Flight reliability goal

An adequate flight reliability goal is that of a conventional four-engine chemical aircraft, capable of sustaining flight on any two engines. Assume that the probability of in-flight of each engine unit is one in 5000 hr of flight and that the average flight is 5 hr duration. Then the flight reliability of each engine unit at the start of each flight would be 0.999, and the flight reliability of the complete propulsion system would be approximately 0.999999996. In other words, chances of losing flying power are about four in a billion flights.

These values can be broken down for the nuclear propulsion system as shown in Figs. 1 and 2 for an indirect-cycle three-loop system. Fig. 1 shows a simplified block diagram for both a single-reactor and dual-reactor system. Fig. 2 shows the order

system

aircraft

best be merged by this

by Martin engineers.

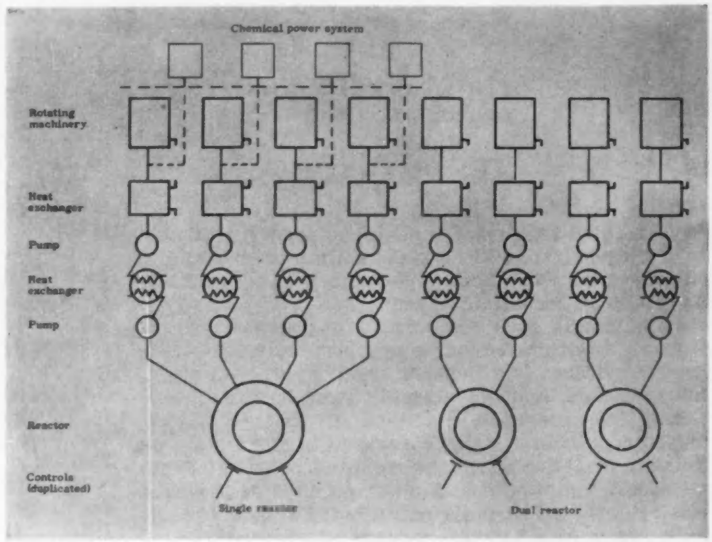


Fig. 1 — Schematic of single-reactor and dual-reactor systems.

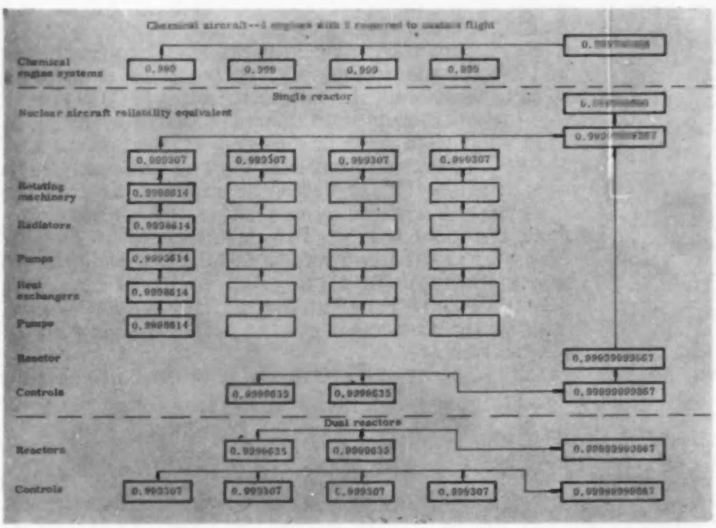
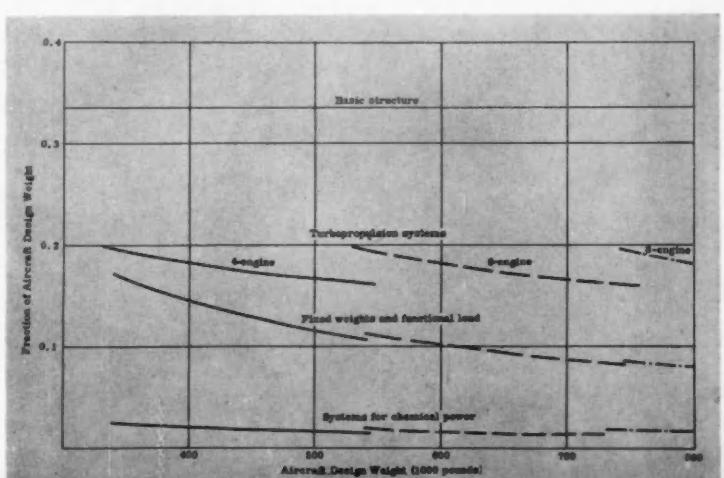


Fig. 2 — Comparison of propulsion system flight assurance reliability requirements.

Fig. 3 — Trends of aircraft weights — exclusive of reactor-shield assembly.



Nuclear Aircraft

. . . continued

of reliability required for each component to result in a system reliability equal to that of the model chemical system. Both series and parallel reliability probabilities are involved.

Establishing such component reliability will have to be by appropriate component system design, testing for design verification, and good inspection, maintenance, and replacement practices in operation. The difference in achieving reliability in nuclear propulsion systems compared to chemical propulsion systems is in the amount of relief from stringent component reliability requirements which can be obtained through redundancy and still result in a reasonable aircraft system.

Although one approach might be to provide alternative chemical propulsion capability, this capability must also be accompanied by a quantity of fuel for range. For nuclear aircraft a range of approximately 1500 naut mi is indicated to make it possible to reach base from any logical operating point. This is significant because, in scaling aircraft size, the fuel required for a given aircraft range is a nearly constant fraction of design gross weight. Increase of fuel fraction to provide additional range for a chemical aircraft (without sacrificing other qualities, removing fixed weights or function load) requires that the aircraft be scaled upward until the fixed weight fractions are reduced sufficiently to allow the new fuel weight fraction of aircraft weight to be absorbed in the design gross weight.

Effect on design

Martin-developed nuclear aircraft designs were used for assessment. Such requirements as low altitude maneuverability, large operating crew, high crew and aircraft utilization, and a substantial payload have led to a preference for turboprop power conversion and unit shields.

Effects of design alternatives on design gross weight were examined. Aircraft performance quality factors, functional load, and crew radiation dose rates were held constant.

For scaling purposes, aircraft weights were grouped into basic structure, propulsion systems (exclusive of reactor shield assembly), and fixed aircraft weights and functional load — and expressed as fractions of design gross weight. Reactor-shield assembly weights (with and without chemical fuel in shield) were determined for the power levels varying with aircraft weight and expressed as fractions of design gross weight — taking into account the effect of varying aircraft dimensions on the distance separating the crew from the reactor.

By adding the reactor-shield assembly weight fractions to the sum of all other aircraft weight fractions at various design weights, a curve was plotted to show the trend of growth with aircraft scaling and the point at which the sum of all the fractions is unity, or the minimum design gross weight. When the sum of all the fractions is less than unity, the difference between the sum and unity represents growth potential.

Fig. 3 shows trends of aircraft weights (exclusive of reactor-shield assembly) as fractions of aircraft design gross weight. Discontinuities in the curves are due to incremental increase in the number of engines — with only one engine type allowed, this factor had major significance. The unusually high structural weight fraction, compared to existing chemical aircraft, is due partly to the aircraft mission, but primarily to two peculiarities of nuclear aircraft: (1) landing and take-off gross weights are about the same, and (2) usual device of obtaining structural load relief by distributing weight — such as placing fuel in the wing — is very limited in application.

Fig. 4 shows weight trends in scaling of reactor-

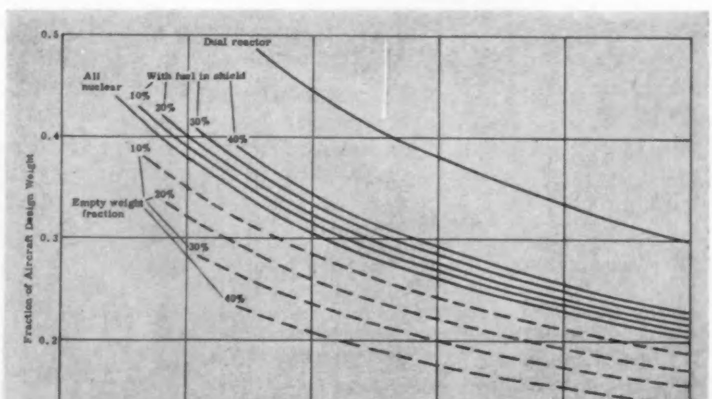


Fig. 4 — Design weight fractions for reactor-shield assembly.

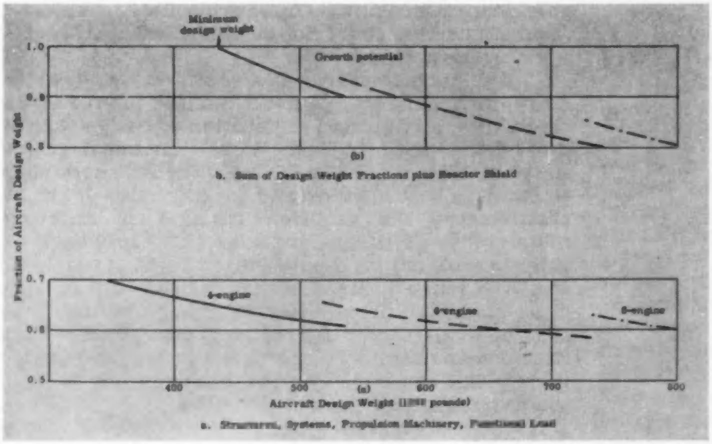


Fig. 5 — Single-reactor aircraft growth trend.

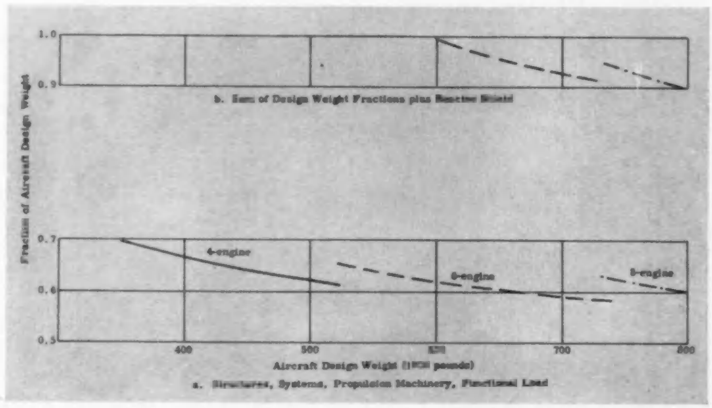


Fig. 6 — Dual-reactor aircraft growth trend.

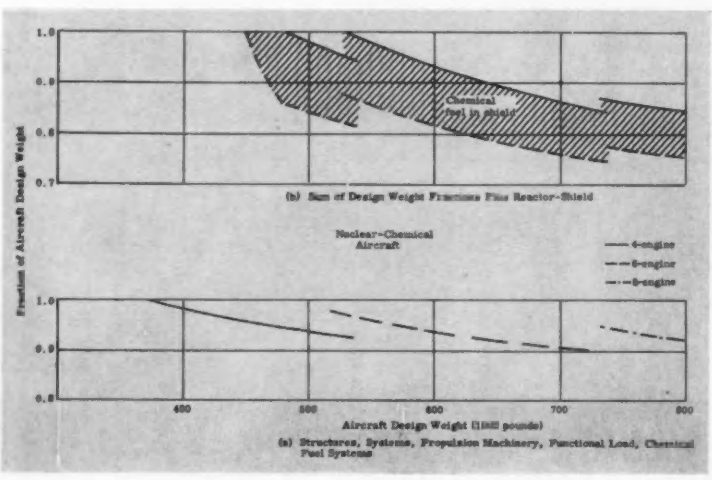


Fig. 7 — Nuclear-chemical aircraft growth trend.

Nuclear Aircraft

. . . continued

shield assemblies as fractions of aircraft gross weights with various amounts of shield weight (0–40%) attributed to chemical fuel.

Fig. 5a shows the sum of the fractions of aircraft weight. In Fig. 5b, the reactor-shield assembly weight fraction for the all-nuclear single-reactor aircraft is added to this sum. Fig. 6 shows the same for a dual-reactor system.

Fig. 7 shows reactor-shield assembly design weight, with near optimum combination of fuel in the shield, added to the sum of aircraft weight plus allowance for adding the required chemical fuel systems. Shading represents fuel in the shield which must be carried when the reactor is operating — to be used only when the nuclear plant is shut down.

Chemical fuel in the shield is useful only when the fuel must be carried for some reason other than shielding. Once designed for a specific amount, the quantity carried could not be varied without affecting crew dose rate.

If the nuclear-chemical aircraft is required to carry chemical fuel against a nuclear plant failure emergency, an appropriate fraction of design weight must be allotted to fuel. For a chemical power range of 1500 nautical mi — with the fuel necessary to climb to best altitude and for minimum loiter at destination — the required fraction is approximately 18% of design gross weight. Influence of this requirement on design gross weight is shown in Fig. 8 — which compares growth potential of nuclear-chemical aircraft having this requirement to that of dual-reactor aircraft. It can be seen that the nuclear-chemical aircraft has grown to approximately the same size as the dual-reactor, with a somewhat inferior growth potential.

If the selection of engines were infinite, more nearly optimum combinations would be allowed. This is shown in Fig. 9, where the curves for the three basic configurations are smoothed.

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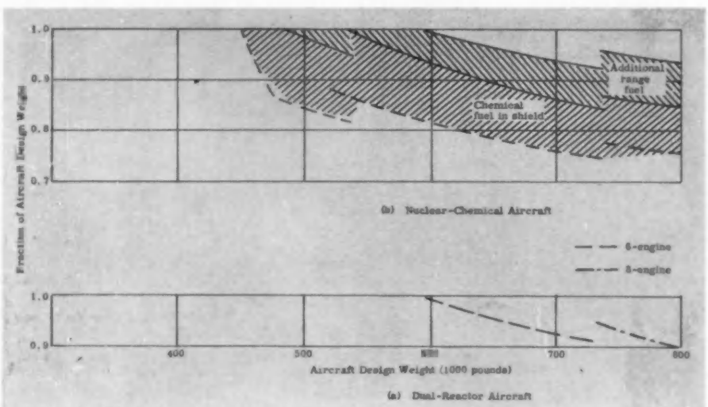

Fig. 8 — For 1500 naut mi emergency chemical cruise range, the nuclear chemical aircraft is about the same size as the dual-reactor aircraft.

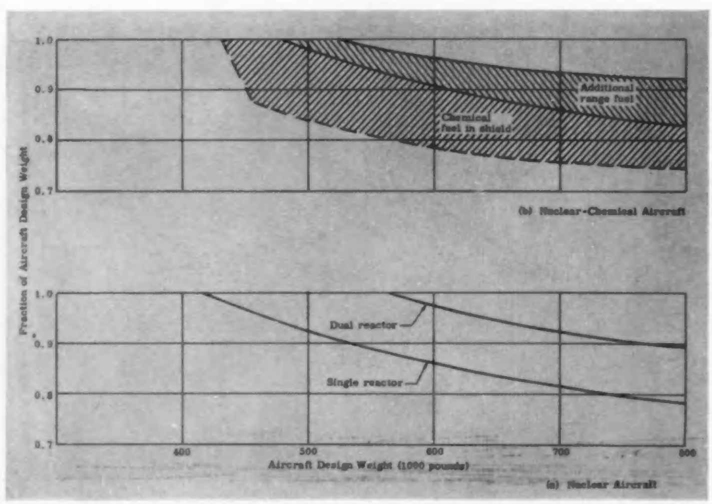

Fig. 9 — How infinite selection of engines would affect the sums of design weight fractions.

High Energy Rates Shape Parts

Explosive, hydroelectric, and pneumatic-mechanical methods of forming are replacing conventional methods for some applications. Reason: lower tooling and lower finishing costs.

Based on paper by **E. W. Feddersen,** Convair — Forth Worth

THREE MAJOR METHODS OF APPLYING HIGH ENERGY RATE to the deformation of metals are explosive, hydroelectric, and pneumatic-mechanical.

EXPLOSIVE FORMING is the shaping of materials by the exertion of sudden pressures from the explosion of a chemical charge. The shock wave and subsequent hydraulic action cause the material to take the shape of its die.

Normally, a medium such as water is used to transmit these forces because the intense heat generated tends to burn the material. Water, or a fluid medium, is also used because a more uniform pressure is experienced from the hydraulic action. A third reason for using a fluid medium is the natural muffling effect it has on the sound of the explosion.

Although possessing certain advantages over mechanical presses, explosive forming cannot replace mechanical means of forming in producing high-volume items. The real advantage lies in the ability to form and size large, complex sections, at fractional tool costs, and the elimination of extremely large mechanical machinery.

THE HYDROELECTRIC METHOD has been described as underwater lightning. Again, the sudden release of energy is applied to deform materials. Here, electrical energy is stored in capacitors and suddenly triggered. The energy, applied through a water medium, is the same as in explosive forming.

This method, like explosive forming, also has its limitations, and does not appear to be a replacement for the mechanical press. Advantages of the hydroelectric process read almost identical to those of explosive forming. However, there are additional advantages which make it more versatile as a production method. The process is accurate and repeatable and, because of complete controllability, usable within a fully inhabited factory.

THE PNEUMATIC-MECHANICAL METHOD, called Dynapak, applies high energy rate to the deformation of materials through the sudden release of compressed gas. Energy is stored in the form of compressed dry nitrogen gas. This gas is released through a system of valves and applied to a piston. The piston, ram, and header plate are driven at very high velocity, making contact with a bolster plate. The header plate contains the punch while the bolster plate holds the die, all of which is conventional, except the high velocities which are employed in the mechanical action. This method opens new avenues of metal forming and can, in some instances, use simple punches with complicated dies.

To Order Paper No.160C . . .
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Typical applications of each of the above high-energy-rate forming methods are described on the following pages.

High Energy Rates Shape Parts

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① Explosive

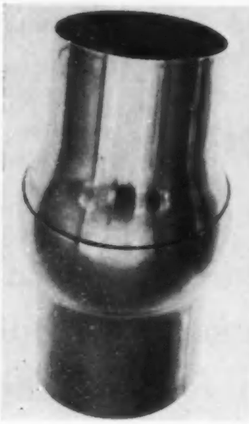

Fig. 1

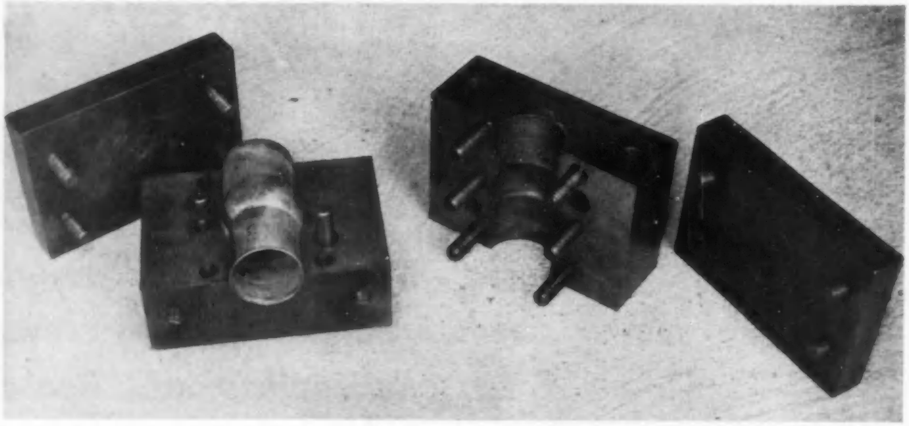

Fig. 2

Fig. 3

Forming a Ball Joint

One application of explosives to the expansion of preformed hollow bodies is shown in Fig. 1. The ball joint is made by precutting 301 annealed stainless steel tubing and nesting one within the other. These are then placed in the die shown in Fig. 2. A light charge of prepackaged gun powder is placed inside the tube and detonated. This results in a uniform semiairtight ball joint for the overboard dump system for the B-58 airplane. Fig. 3 shows two ball joints fitted to attaching flanges resulting in a universal joint in the anti-icing system for the B-58.

Forming a Ramjet Engine Cooling Shroud

Another application of explosives to preformed hollow bodies is shown in Fig. 4. This part is a cooling shroud for a ramjet engine. Here, a type 310 stainless steel was preformed into a cylinder and welded. It was placed in the die shown in Fig. 5 and a cylindrical charge of PETN explosives, 2 in. in diameter and 9 in. long, was suspended within the chamber. The result was a complicated part formed without the need of machine tools. Conformation of convolutions and diameters were within tolerances of ± 0.010 in.

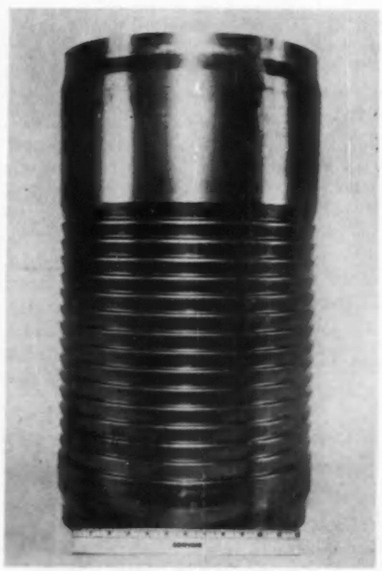

Fig. 4

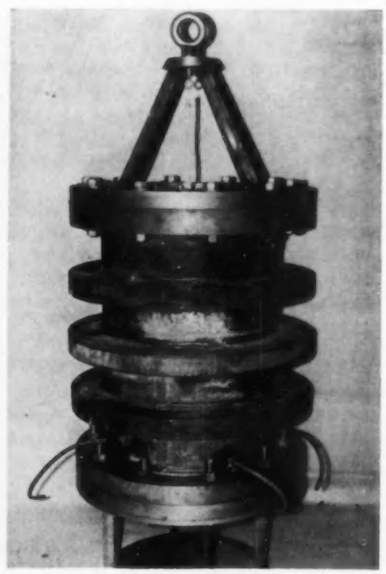

Fig. 5

Forming

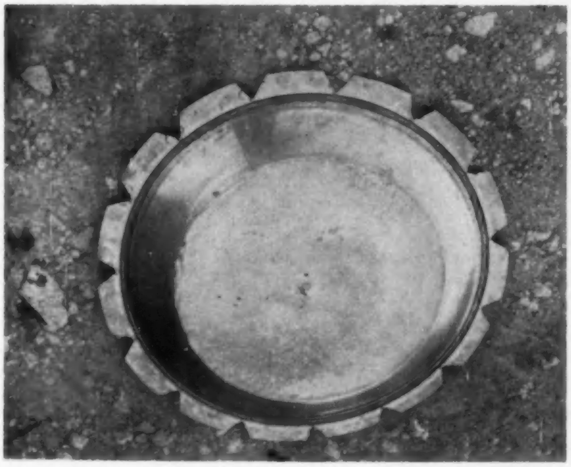

Fig. 6

Fig. 7

Forming a Regular Cup Shape

The application of explosives in forming a regular cup shape is shown in Fig. 6. Here, the requirement was for the part to be made from 301 ½ hard stainless steel, 24 in. in diameter and have a 4-in. chord height. The tool (Fig. 7) for this cup-shaped part was made in two pieces. The base is cast Kirksite with the hemispherical form and a steel draw ring. The upper case serves two purposes. First, it acts as a draw ring and, secondly, as a water tank in which the explosive charge is placed. The formation of this hemisphere is interesting because multiple charges created stresses within the material that caused the part to warp when trimmed. Although many variations of explosive charge sizes and shapes were tried, the hemisphere could only be formed with a single charge. The ½ hard 301 material had to be fully trapped to prevent compression wrinkles.

Forming an Irregular Cup Shape

An irregular cup shape which was selected for explosive forming because of the multiple strike and annealing operations which were required when the part was made on a drop hammer is shown in Fig. 8. Operations were reduced by explosive forming from five strikes to three and from four anneals to one. The part, a mounting for a ground cooling line on the B-58 is made from 6061-0 aluminum and is formed using two 5-g explosive charges with only one annealing required between strikes.

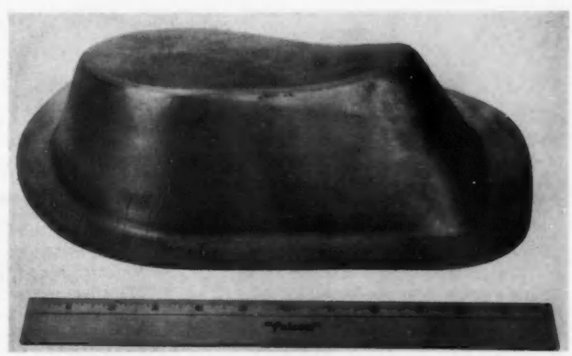

Fig. 8

more on High Energy Rates Shape Parts →

② Hydroelectric Forming

Hi-Vo-Pac Unit

The high-energy spark unit used in hydroelectric forming is shown in Fig. 9. The portable metal box on the left contains capacitors, switching circuits, varaic control of power, charging switch, and automatic or manual discharge switches. The desired voltage build-up is controlled by the variac and can be read in the voltmeter located on the control panel. Build-up and discharge after making the desired setting is initiated by merely pressing the release button. Upon activating this button, the unit charges in 6 sec and then automatically discharges.

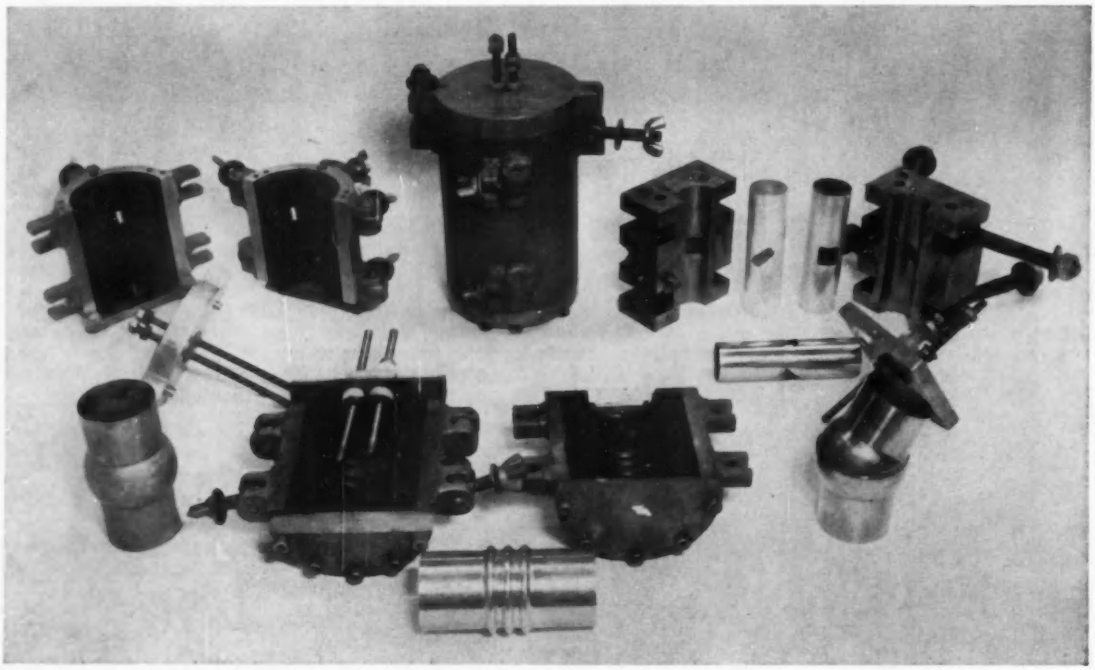

Fig. 10

Hi-Vo-Pac Dies

In the application of the controlled and repeatable electrical explosive force, the most obvious departure from explosive forming is in the die design. Dies for high-energy spark forming are completely closed. Fig. 10 shows several dies for forming airframe components. The closed die in the top center of Fig. 10 contains fixed electrodes to which is attached the initiating wire. The position of the electrode has been determined by experiments to give the most efficient wave front for the forming to be done.

Each die has its own peculiar set of electrodes and initiating wire. The dies can be completely closed because the gas volume generated by the vaporized wire is insignificant, if compared to the gas bubble created by a chemical explosive. By closing the die, full advantage can be taken of the pressure wave and, in the case of tubular parts, the shock wave is reflected off the ends, creating additional energy.

The closed die design permits the use of epoxies as die material. Epoxy resins have high compression strength and reasonable wear characteristics. Standard shells in which the pattern is held, are of various diameters. Resin is poured while the die is vibrated. This is essential if all trapped air is to be expelled from the resin. The die is completed in about two days, including curing time for the epoxy resins.

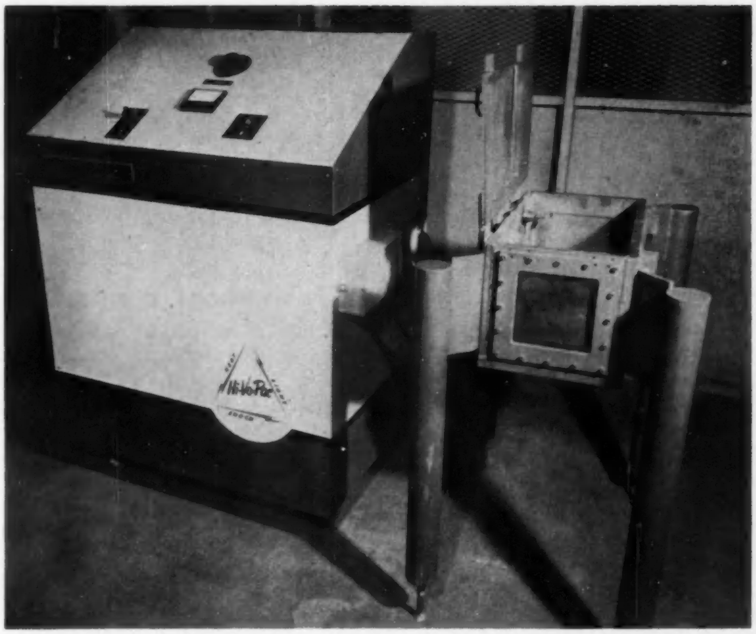

Fig. 9

Split Die, Blank, and Die Head Electrode

The following sequences are necessary operations in the forming of a part by the hydroelectric process (Fig. 11). The die is closed and the bottom plate installed. The tube to be formed has a rubber wafer installed at its base, making the tube water tight. The tube is then placed into the die cavity and the tube filled with water. The cover plate with electrodes and initiating wire is installed. The leads from the power unit are connected to the electrodes, and the release button is pressed. In 6 sec, the unit charges and fires automatically, resulting in the finished part shown in Fig. 12. Note that the operations of bending, expanding, and piercing of the hole were done simultaneously.

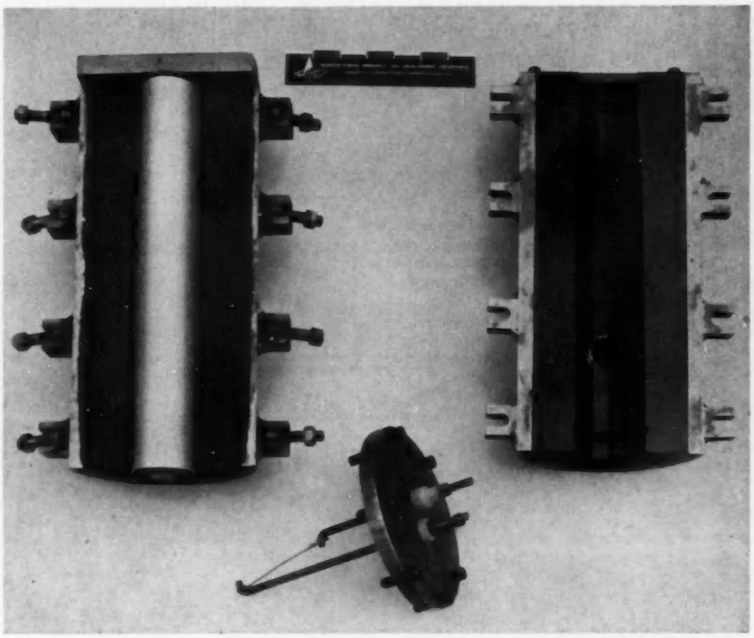

Fig. 11

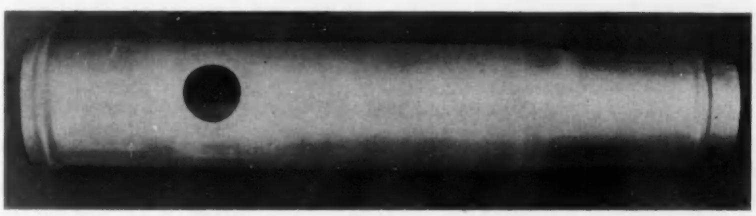

Fig. 12

more on High Energy Rates Shape Parts →

High Energy Rates Shape Parts

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③ Pneumatic-

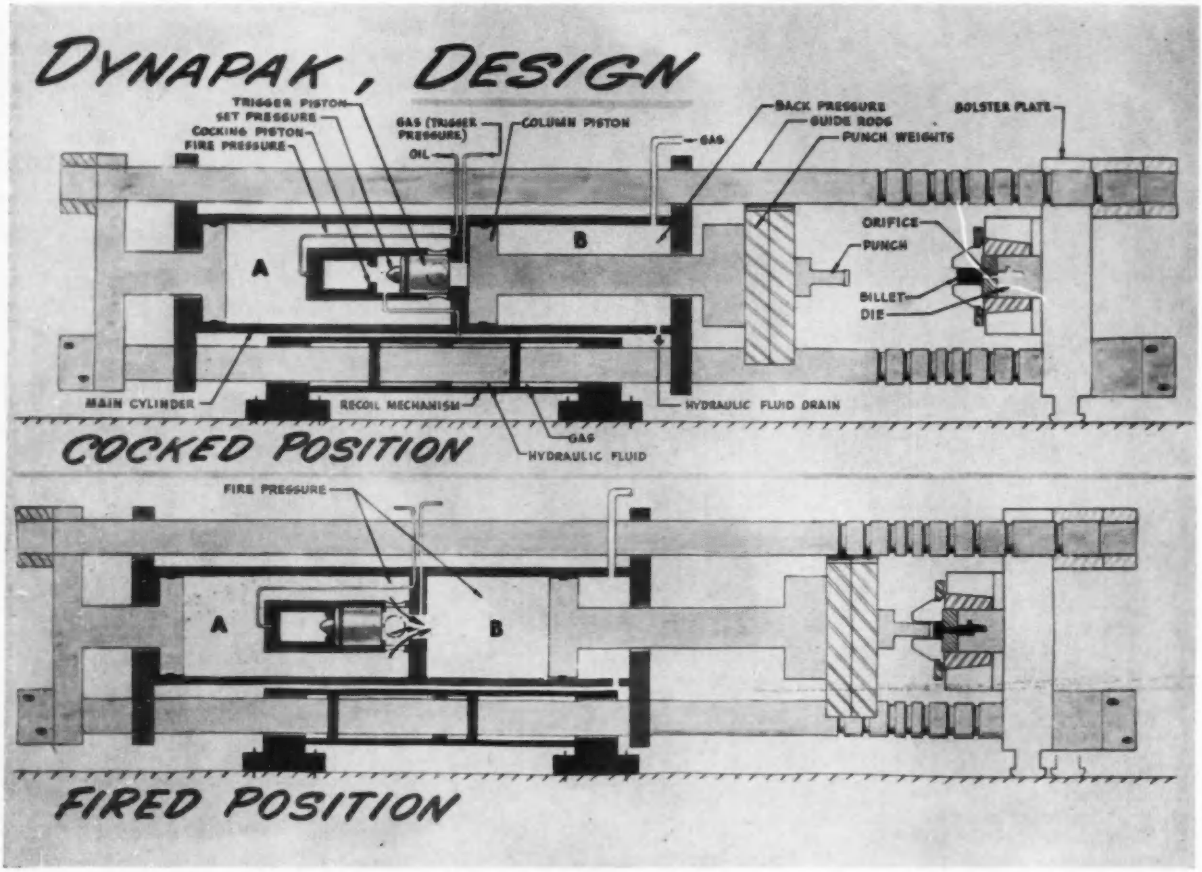

Fig. 13

Dynapak Machine

A schematic of the machine is shown in Fig. 13. It consists of a two-chambered cylinder, valve cocking assembly, piston ram assembly, bolster plate, tie rods, cushioning piston, nitrogen shock absorbers, and base frame. The entire unit can be mounted either in a horizontal or vertical position.

The operation of the machine is as follows: Chamber A is charged with nitrogen gas to the desired fire pressure. A trigger pressure is then applied to the small area between chambers A and B. This trigger pressure forces the trigger piston to an open position. Compressed nitrogen gas then passes through three large ports and acts upon the piston, driving it and the punch toward the workpiece at a high velocity. Because the machine is mounted on a floating type support, the bolster plate also moves toward the punch, when the machine is fired. The momentum from these two sources cancel each other as the part is formed. Therefore, all stresses are contained within the machine.

After the part is formed, the piston is returned to the cocked position by pumping hydraulic oil into the forward section of chamber B. This action also recompresses the nitrogen gas into chamber A to the original firing pressure. By changing the firing pressures the energy is varied, and by changing the weight the velocity of the ram is varied.

Mechanical Forming

Dynapak is a pneumatic-mechanical machine which releases stored high-pressure nitrogen gas to accelerate a piston to a high velocity. This principle of forming offers to the metal forming industry a high energy rate device which can be used in forging, extruding, compacting, shearing, and blanking.

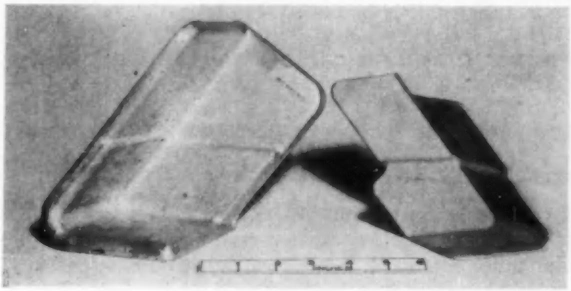

Fig. 14

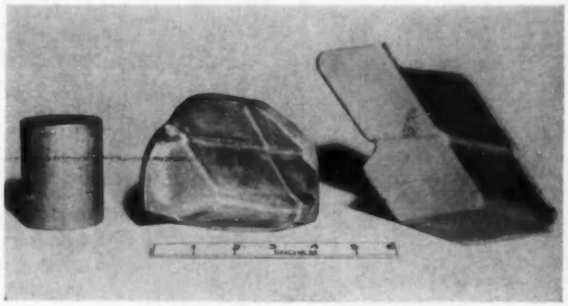

Fig. 15

Forged Gas-Tight Part

The pneumatic-mechanical form of high energy rate was used to produce a forged gas-tight corner which is structurally sound and required a minimum of machining. The part, shown on the right in Fig. 14, is used in the Convair 880 airliner. It was being machined from the 4-lb 10-oz blocker forging, shown on the left in the same photo, to a finish weight of 10 oz.

The same part finished forged from 2014 aluminum alloy in two strikes is shown in Fig. 15. The only machining required is the flash trim and the attach hole drilling. This method of producing the gas-tight corner has resulted in a dollar savings of approximately 63% over the original method.

Hot-Forged 19-9 DL Stainless Steel

An example of what can be done with high energy rate applied to a part made from 19-9 DL stainless steel is shown in Fig. 16. This part had been machined from typical blocker forgings. By applying the high energy rate principle, the results showed a reduction of raw materials from \$3.20 to \$0.84. Tooling costs were reduced from \$1200 to \$600, and machining operations reduced from 7 to 2. The result of the above reductions was a 75% overall savings by the customer. Another major factor was realized when this process was applied to forge the flange. When forged at 2100 F and hot-cold worked at 1500 F, greater strength and more uniform and controllable work-hardening resulted.

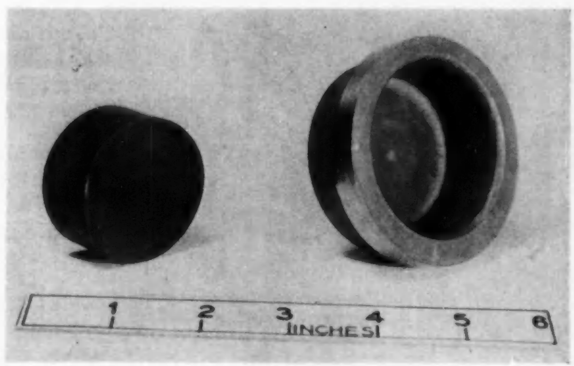

Fig. 16

TRANSISTOR-SWITCHED IGNITION SYSTEM MAY REPLACE INDUCTION COIL

... for applications where a premium can be paid for reliability.

Induction Coil versus Slow Coil

Reduction of back voltage in conventional ignition coils is impossible because they operate on the induction coil principle. A high-tension transformer, the slow coil of yesteryears, had to be considered if germanium transistors were to be used for transistor switched ignition systems.

The **high-tension transformer** was abandoned in the early 1920's in favor of the induction coil for reasons both economic and operational.

The **induction coil** was smaller, lighter, and cheaper to construct. In addition, the induction coil with its 1500 to 2500 cycle secondary wave front exhibited appreciably better ability to fire carbon-fouled spark plugs than the approximately 500 cycle transformer. This difference in performance under resistive load is shown in Fig. 4. (See page 49.)

On the other hand, the **induction coil, with its inherently high primary inductance and high primary-induced voltage,** brought with it much more serious contact problems. These characteristics of the induction coil are capable of initiating and sustaining an appreciable arc at the separating contacts resulting in severe burning and metal transfer (Fig. 13). (See page 51.)

The **early ignition coils** took this more or less in stride since a relatively low primary current could provide adequate voltage for the low compression engines of that day. The increased current requirements of modern ignition, however, have seriously shortened contact life.

The return to the **slow coil** provides a measure of relief in contact life, permits the use of transistors, and gives at least equal performance under fouling conditions.

Based on paper by

G. E. Spaulding, Jr.

Electric Autolite Co.

A HIGH-VOLTAGE TRANSISTORIZED IGNITION SYSTEM has been designed which can be used interchangeably with the present conventional induction coil. Using a slow coil (high-tension transformer) the transistorized system features:

1. **Voltage output** which is relatively flat throughout the engine speed range.
2. **Reduced contact** current giving unlimited electrical life and reliability of contacts.
3. **Performance** under fouling conditions at least equal to the present induction coil.
4. **Voltage ceiling flexibility** — the voltage can be raised to provide for possible future engine designs.

Transistorized ignition circuit

Fig. 1 shows a transistorized ignition circuit. The principle of operation is based upon the transistor's ability to amplify current. When the contacts close, a small current flowing through the emitter-base circuit will switch on the transistor permitting a larger current to flow through the emitter-collector (Fig. 2). The current gain, or amplification factor, is a function of this transistor itself.

Fig. 3 shows the current carried by the electrical contacts compared to the current switched by the transistor. The amplification is about 30 to 1; contact current is about 0.250 amp while transistor or system current is approximately 7.5 amp.

The relatively flat output voltage (Fig. 4) is obtained because of the fast rise of current to design value due to the relatively low primary inductance.

Diode D_1 (Fig. 1) provides a means of reverse biasing the emitter to base junction when the distributor contacts S_1 are open. This insures transistor cut-off even at high temperatures. Resistor R_1 allows a small current to flow through D_1 continuously, thus there is a 0.5–0.75 v drop across D_1. Since the transistor base is connected to the positive side of the diode through R_2 and the emitter is directly connected to the negative side of the diode, when the contacts are open, the base is at a potential of 0.5–0.75 v positive with respect to the emitter which guarantees transistor cut-off. This action is enhanced by keepng R_2 as low as possible but R_2 cannot be too low or it would allow too much current to flow through the contacts on make.

The diode has a peak inverse voltage rating of sufficient magnitude to protect the circuit in case it is connected with reverse polarity. During the dwell period when the contacts are closed, the transistor base is directly connected to the collector, allowing maximum current to flow. Transistor impedance when full on is about 0.10 ohm. Initial current flow is limited by the inductance of the primary of the high-voltage transformer T_1 but finally by the ballast R_3. Note that the traditional condenser across the primary contacts (S_1) has been eliminated.

Figs. 5 and 6 compare the characteristic voltage wave forms induced in the primary and secondary of the conventional and transistorized systems. The primary induced voltage of the transistorized system

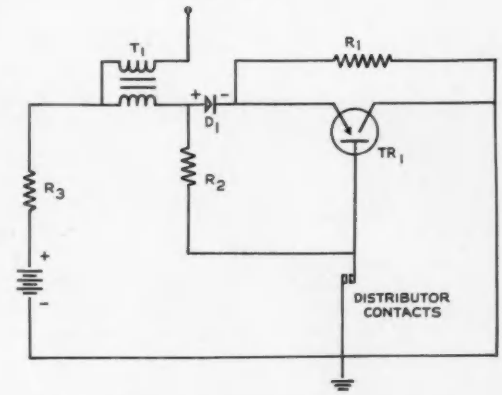

Fig. 1 — Transistor switching high-voltage ignition system.

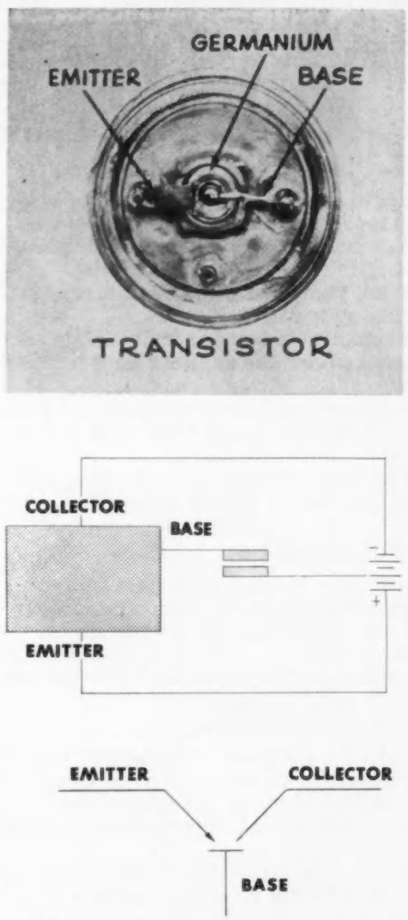

Fig. 2 — Transistor — photograph with cover removed (top), simplified circuit diagram (center), and schematic symbol (bottom).

TRANSISTOR-SWITCHED IGNITION SYSTEM MAY REPLACE INDUCTION COIL

... continued

is about 60 v; about one-fifth the voltage induced in the induction coil primary (Fig. 5). The frequency of the secondary voltage wave of the induction coil is about 1500 cycles as opposed to a 400-cycle wave in the slow coil (Fig. 6).

Design features and advantages

Thus, a high-voltage transistorized ignition system has been designed which can be used interchangeably with the present conventional induction coil (Fig. 7). Its design features and advantages are:

1. Voltage output is relatively flat throughout the speed range (Fig. 4).
2. Contact current has been reduced giving unlimited electrical life and reliability of contacts (Figs. 3, 8, 9).
3. Performance under fouling conditions is at least equal to the present induction coil.
4. By appropriate changes in system parameters, the voltage ceiling can be lifted on demand to provide for possible future engine designs.
5. The coil package is rugged and may be located in ambients up to 350 F (Fig. 10).
6. The separate transistor heat sink permits location in areas where the ambient does not exceed 180 F (Fig. 10).
7. The system is designed for negative ground and is protected against inadvertent reversal of primary polarity.
8. The system is adequate for starting with battery voltages as low as 6 v in a 12 v system.

Immediate applications

Obviously, the price of the package will be high when compared to the coil and condenser it will replace. There are, however, certain commercial applications which can justify the added cost when overall system reliability and longevity are prime economic factors. Some applications which appear to offer a ready market are:

1. Stationary engines providing pumping or standby power for the utilities industries.
2. Stationary engines providing power for heat pumps, air conditioning units, irrigation pumps, and such.
3. Certain commercial fleet applications.
4. Certain off-the-road and agricultural equipment applications.

Future applications

Several methods of combating the fouling problem through system design have intrigued designers

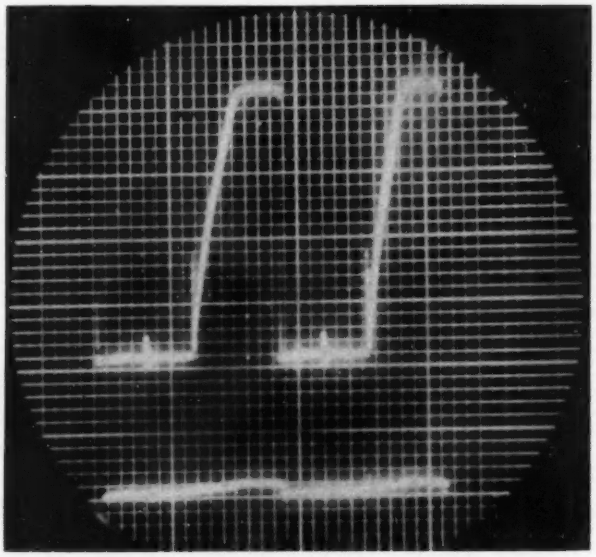

Fig. 3 — Current amplifying characteristics of transistor in ignition system. Collector current switched by transistor (top), base current switched by contacts (bottom). Horizontal axis: 13.7 milliseconds per inch. Vertical axis: 5 amperes per inch.

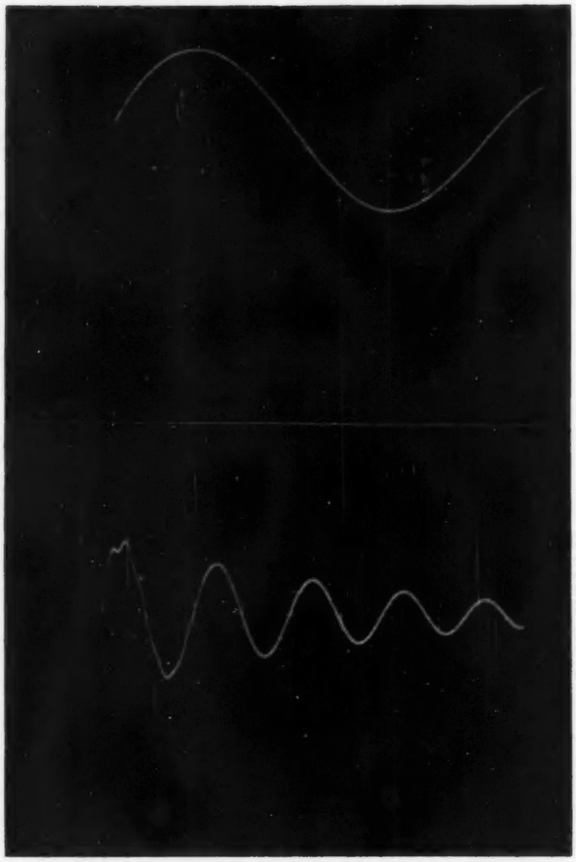

Fig. 6 — Secondary wave forms of transistorized ignition system and conventional ignition systems compared. Secondary voltage of transistorized system (top). Secondary voltage of conventional system (bottom). Dual beam oscilloscope. Horizontal axis: 250 microseconds per centimeter. Vertical axis: 10 kilovolts per centimeter.

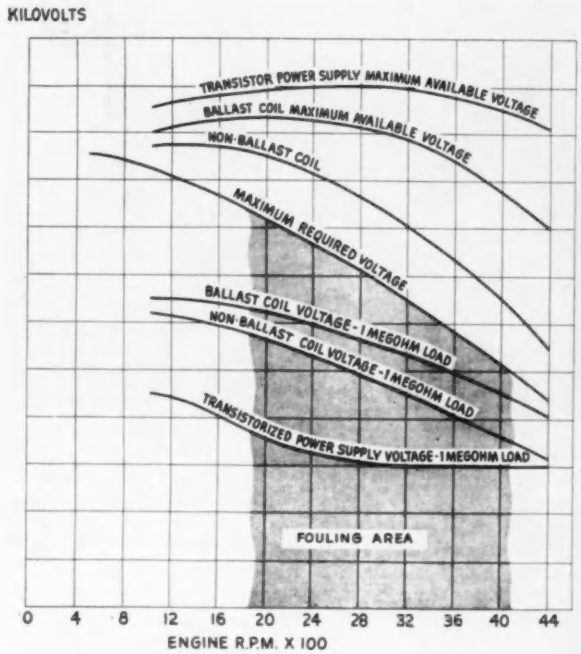

Fig. 4 — Comparative performance of transistor and conventional ignition systems.

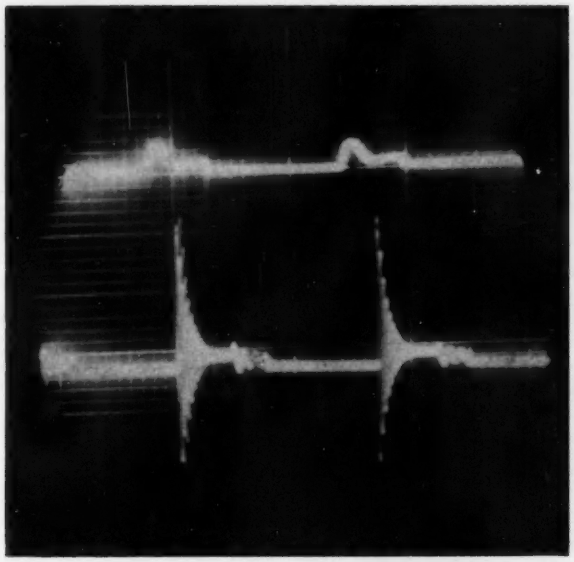

Fig. 5 — Primary wave forms of transistorized and conventional ignition systems compared. Primary voltage of transistorized system (top). Primary voltage of conventional system (bottom). Dual beam oscilloscope. Horizontal axis: 13.7 milliseconds per inch. Vertical axis: 500 volts per inch.

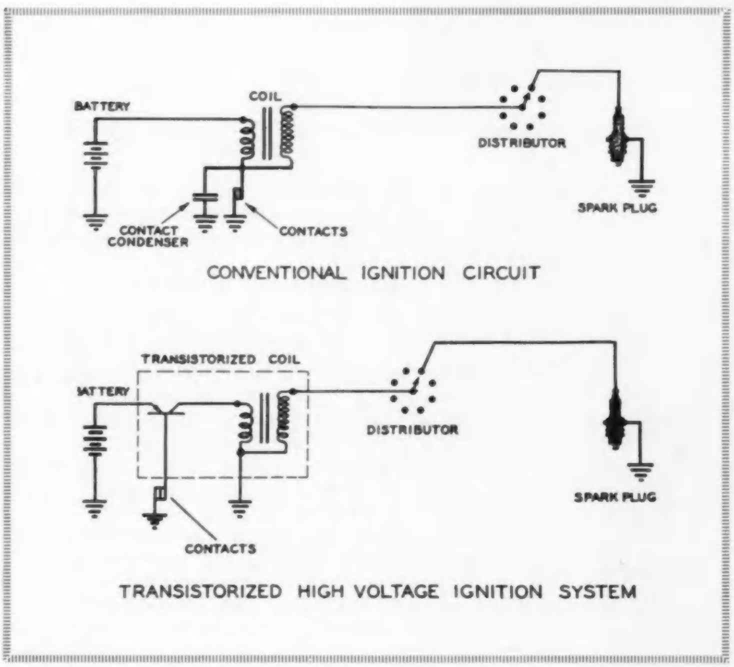

Fig. 7 — Schematic diagrams of conventional and transistor-switched high-voltage ignition systems.

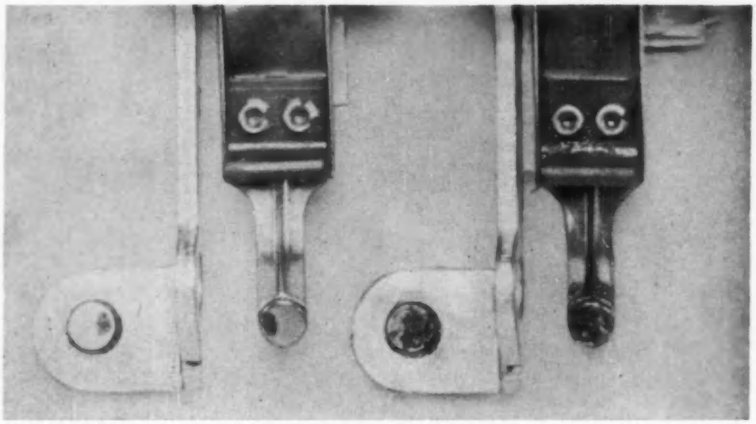

Fig. 8 — Direct comparison of contacts from systems after 44,000 miles endurance tests.

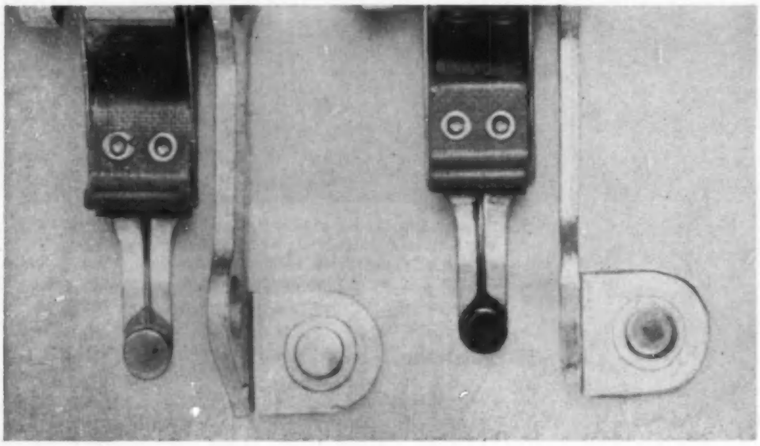

Fig. 9 — Direct comparison of contacts from systems after accelerated cold tests at − 20 F.

TRANSISTOR-SWITCHED IGNITION SYSTEM MAY REPLACE INDUCTION COIL

. . . continued

for many years. Although there is considerable difference in configuration of the various systems and their components, they all have at least two characteristics in common:

1. They involve charging a capacitor and then discharging it across the spark gap. This results in an extremely high frequency discharge, usually in excess of one megacycle. These systems will, then, cause a spark to occur at the plug even with low values of shunt resistance.

2. They all require more energy input than is available with conventional switching techniques.

A second, and concurrent, phase of our development program involved the application of transistor switching concepts to the more promising antifouling systems.

Two basic types of systems are involved:

1. High voltage — auxiliary gap (Fig. 11)
2. Low voltage — condenser discharge (Fig. 11)

Although there have been reputable brand spark plugs on the market for years incorporating series gaps, their use has been restricted to special applications. The induction coil system is not capable of developing the voltage required by the combination auxiliary — spark plug gap at starting and throughout the speed range (Fig. 12).

The transistorized system makes adequate voltage available as shown in Fig. 12. With the energy problem solved, research now revolves around development of an optimum series gap configuration.

The second system under development requires the use of special shunted surface gap spark plugs. A schematic of the system is shown in Fig. 11.

To Order Paper No. 132A . . .
. . . on which this article is based, turn to page 6.

Fig. 10 — Prototype transistorized ignition system.

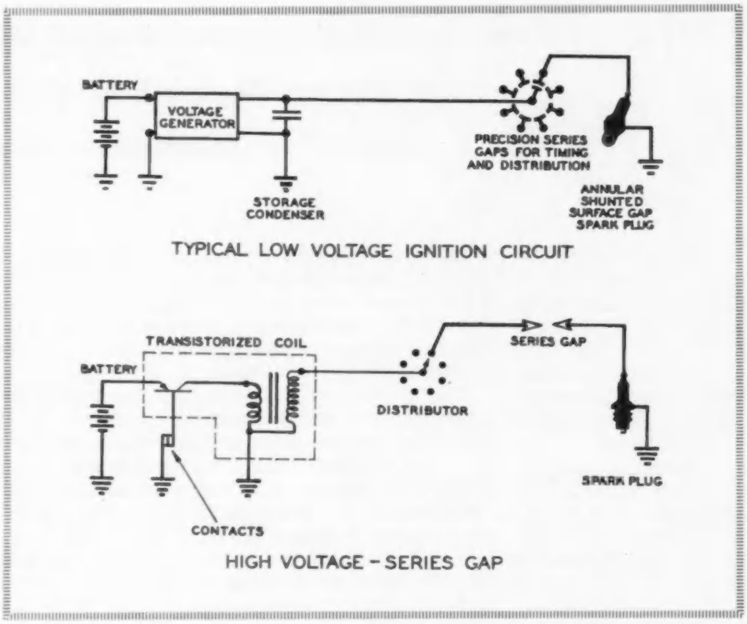

Fig. 11 — Schematic diagrams of practical series-gap and low-voltage antifouling ignition systems utilizing transistor switching technique.

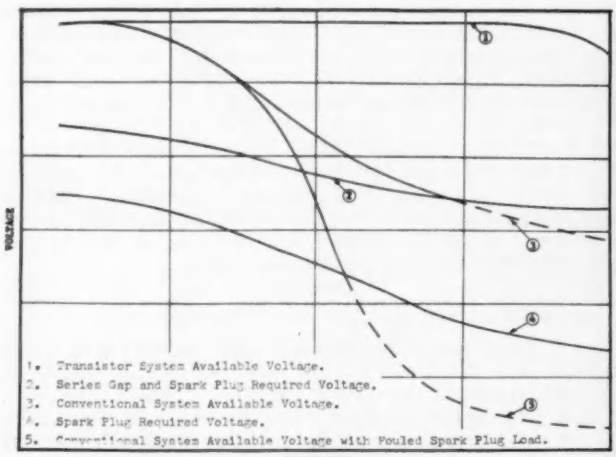

Fig. 12 — Typical available and required voltages for transistor-switched, series-gap, and conventional ignition systems over engine speed range.

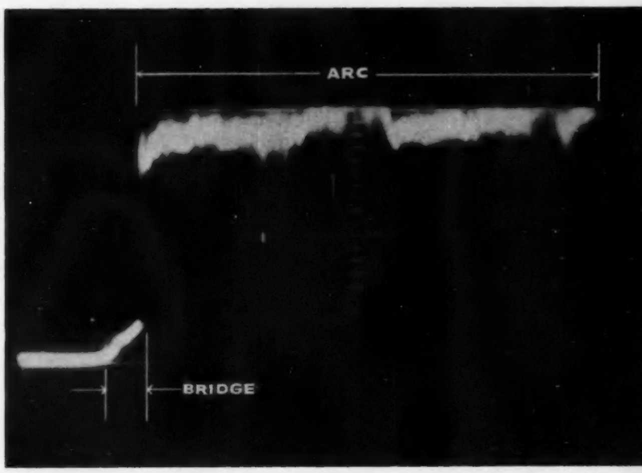

Fig. 13 — Photograph of bridge and arc between breaking contacts in induction coil system.

New Energy-Storing Device

Solar-to-Electric Energy

▸ Measured potentials of experimental cells are consideration. Research to reduce high pay off in higher maximum power

Based on paper by

Bert H. Clampitt and Dale E. German

Physical Sciences Staff, Boeing Airplane Co.

NEW TWO-STAGE DEVICE for converting solar energy into electrical energy promises operating efficiencies comparable with current photovoltaic devices — and acts as its own storage battery.

First stage will convert solar to chemical energy by the photochemical isomerization of trans to cis organic acids. (Cis and trans indicate two forms of geometrical isomers.) The next stage converts chemical to electrical energy by means of electrochemical concentration cells.

Concentration cells using cis and trans acids have been constructed, and potentials approaching the theoretical value of about 0.1 v were measured. Maximum electrical power measured in the various systems was 2–3 microwatts per sq cm of electrode area, despite high internal resistances. Techniques for reducing these resistances are being investigated.

Method

Ultraviolet radiation causes geometrical isomers to change from one molecular configuration to another. The photostationary state of the isomers (that is, the equilibrium concentration of the cis and trans forms under ultraviolet illumination) favors the cis form. As the cis form is thermodynamically less stable, some of the radiant energy is stored as chemical energy.

The next step is to recover the stored chemical energy in an electrochemical manner. If two solutions containing the same ion at different concentrations are connected by an ion bridge, a potential difference exists as a result of the concentration difference. Such an electrochemical cell is known as a concentration cell.

Table 1 shows the various physical properties of cis and trans acids that are of interest in the proposed electrochemical mechanism. The cis-isomer is always much more soluble than the trans-isomer, and it also has a higher dissociation constant. Both the cis and trans acids will ionize in water to give hydrogen ions. However, because of the differences in the dissociation constants and solubilities, there will be more hydrogen ions in a saturated cis-acid solution than in the corresponding trans-acid solution. Therefore, a potential difference will exist between saturated cis-acid and trans-acid solutions when these are connected by an ion bridge.

Using the data in Table 1, cells composed of saturated solutions of the various cis-trans isomers would have theoretical potentials as follows: maleic-fumaric, 0.095 v; citraconic-mesaconic, 0.083 v; cis-trans cinnamic, 0.095 v. Experimental cells of the first two systems have been constructed.

Table 1 — Physical Properties of Various Cis-Trans Acids

	Molecular Weight	Dissociation Constant	Solubility at 25 C (Molality)
Maleic Acid	116	1.15×10^{-2}	6.72
Fumaric Acid	116	9.1×10^{-4}	0.06
Citraconic Acid	130	3.33×10^{-3}	27.7
Mesaconic Acid	130	7.75×10^{-4}	0.21
Cis-Cinnamic Acid	148	1.32×10^{-4}	1.12
Trans-Cinnamic Acid	148	3.7×10^{-5}	0.0027
Angelic Acid	100	4.9×10^{-5}	To be determined
Tiglic Acid	100	9.4×10^{-6}	To be determined

Construction of solar concentration cell

Fig. 1 shows the proposed solar concentration cell. In the operation of the cell, both sides would be filled with a saturated solution of the trans acid. A large excess of the solid trans acid is placed inside A, and this side is exposed to the incident radiation while side B is shielded.

The dissolved trans-acid on side A is changed photochemically into the cis form of the acid re-

Promises Efficient

Conversion

low, but warrant further

internal resistance should

per unit electrode area.

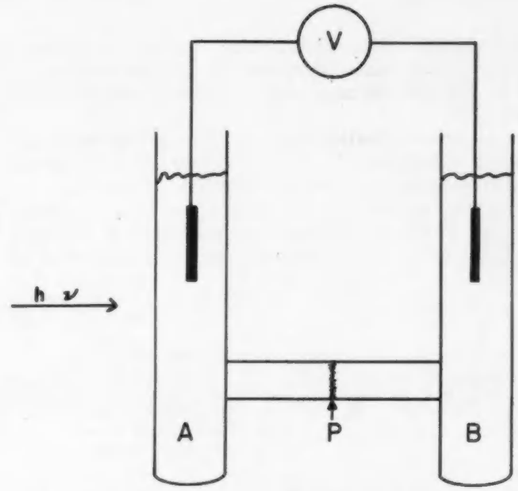

Fig. 1 — Proposed solar concentration cell. Side A is exposed to incident radiation. ($h\nu = E$, where E is the energy of each quantum of light of frequency ν, and h is Planck's constant.) Side B is shielded; P is porous disk.

sulting in the solution of more and more of the solid trans acid. It has been verified experimentally that, even in an unstirred solution, a large dissolution of the solid trans acids occurs in saturated solutions of trans acid under the influence of ultraviolet light. This indicates conversion to the cis form and subsequent dissolution.

The trans-to-cis isomerization occurs whether or not current is being drawn from the cell. In fact the longer the cell is irradiated before power is drawn from it, the larger the power that is available. Provided the cell is "charged" during a period of daylight, current may be drawn in either periods of daylight or darkness.

Experimental concentration cells identical to that shown in Fig. 1 have been constructed. Because they were made of "Pyrex" glass which is opaque to ultraviolet radiation, photochemical conversions were not carried out in them. They were filled with various concentrations of cis and trans acids. Open circuit voltages were measured; Table 2 shows the results. In the cases where the inert salt, potassium chloride, was added, the potentials are equal to or greater than the theoretical values calculated by equation. The potentials greater than the theoretical probably indicate the solutions are not ideal (activities should be used in place of concentrations). Errors in reported solubilities could also explain these results; or the liquid junction potential may be responsible. However, the presence of potassium chloride makes the latter alternative seem remote. It is felt that the potassium chloride functions only to lower the internal resistance.

Discussion

Table 3 shows the heats of isomerization of the various cis-trans systems, together with the calculated maximum wave length of incident radiation necessary to promote the isomerization.

Note that the maximum wave lengths necessary to promote the trans-to-cis isomerization in these compounds occurs in the infrared region of the spectrum — while all experimental investigations have been conducted in the higher energy ultraviolet region. There is no apparent reason for the reaction not proceeding in visible light. For the acids indicated, the probable reason that the trans-cis isomerizations haven't been observed in the visible is that the solutions are transparent in this

Table 2 — EMF of Cis-Trans Concentration Cells

System	Concentration of Cis-Acid, Molality	Concentration of Trans-Acid, Molality	Concentration of KCL	Theoretical EMF, v	Experimental EMF, v
Maleic-Fumaric Acid	0.060	0.060	—	0.033	0.006
Maleic-Fumaric Acid	0.060	0.060	1N	0.033	0.035
Maleic-Fumaric Acid	0.060	0.060	2N	0.033	0.035
Maleic-Fumaric Acid	6.72	0.060	—	0.095	0.010
Maleic-Fumaric Acid	6.72	0.060	1N	0.095	0.111
Citraconic-Mesaconic Acid	0.21	0.21	—	0.019	0.002
Citraconic-Mesaconic Acid	0.21	0.21	1N	0.019	0.024
Citraconic-Mesaconic Acid	27.7	0.21	—	0.83	0.008
Citraconic-Mesaconic Acid	27.7	0.21	1N	0.083	0.100

spectral region. Research aimed at finding a photosensitizer to cause the cis-trans isomerization to occur in the visible region of the spectrum is being carried out.

The amount of chemical energy available from saturated solutions of cis and trans acids is given by the free energy of isomerization. These are approximately equal to the heats of isomerization shown in Table 3. Maximum efficiencies for the conversion of chemical energy to electrical energy have been calculated and are also shown in Table 3. These efficiencies are comparable to the maximum efficiency calculations for most heat engines.

The experimental concentration cells were operated at various external resistances in order to determine the maximum power per unit electrode area. Figs. 2 and 3 show the results for saturated maleic-fumaric acids in one normal potassium chloride and for saturated citraconic-mesaconic acids in one normal potassium chloride. Maximum in the curves corresponds to the maximum power obtainable from the particular system. These curves substantiate what can be proved theoretically — that the maximum power occurs at the point where the external resistance equals the internal resistance.

Despite the fact that these concentration cells contained a large amount of inert salt, the internal resistances were large; about 800 ohms in the maleic-fumaric, and about 1200 ohms in the citraconic-mesaconic system.

Most probable cause of the high internal resistance is the existence of the porous disk separating the two half cells. In all of the experiments reported, the disk was of "fine" porosity; however, experiments using disks of different porosity are contemplated. Another way of separating the two half cells and greatly lowering the internal resistance would be to use an anion permeable membrane. These could be made permeable to maleate ions alone, and thereby such a low internal resistance separator would also reduce thermal diffusion losses to zero. If the internal resistance of the concentration cell can be lowered, the maximum power per unit electrode area can be very considerably increased.

While Figs. 2 and 3 indicate power per unit electrode area, this should not be confused with the geometrical size of the electrode or the area of the solution exposed to the incident radiation. It is possible to obtain physically small electrodes possessing very high surface area; and these electrodes need not be exposed to the radiation for the operation of the cell. From the standpoint of ultimate power, the important factor is the total radiation absorbed by the cell solution. This is a function of the exposed solution area, light intensity, solution absorptivity and length of the absorption path. All of these factors may be varied at will by appropriate means.

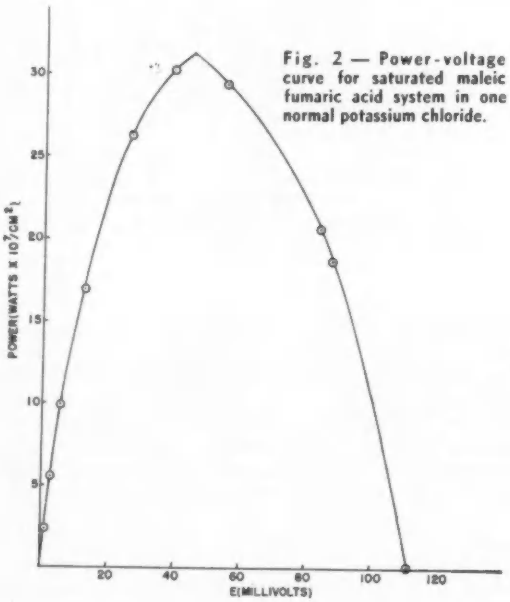

Fig. 2 — Power-voltage curve for saturated maleic fumaric acid system in one normal potassium chloride.

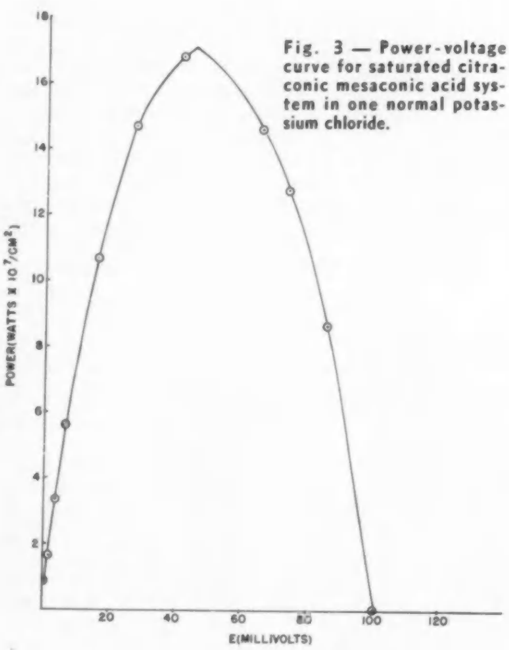

Fig. 3 — Power-voltage curve for saturated citraconic mesaconic acid system in one normal potassium chloride.

To Order Paper No. 159F . . .
. . . on which this article is based, turn to page 6.

Table 3 — Energy Relationships in Cis-Trans Acid Systems

System	Heat of Isomerization (kcal/mole)	Maximum Wave Length[1] (angstroms)	Maximum Wave Length[2] (angstroms)	Maximum Electrochemical Efficiency, %
Maleic-Fumaric Acids	6.1	46,800	10,900	35.6
Citraconic-Mesaconic Acids	2.7	105,500	12,600	70.5
Cis-Trans Cinnamic Acids	6.8	42,000	10,600	32.0
Tiglic-Angelic Acids	8.4	33,900	10,000	

[1] No activation energy is assumed.
[2] Activation energy of 20 kilocal/mole assumed.

Do's and Don'ts to Develop . . .

Qualified CSD Systems

Based on paper by

A. V. Chavez and J. L. Burgess

Boeing Airplane Co.

CONSTANT-speed-drive systems can be designed to qualify on all counts without costly retrofit programs. There are four simple rules for vendor and airframe manufacturer to follow. These are:

1. Assume that any malfunctions that occur — even very minor ones — will grow up to plague the production article. Act to obtain a very positive design fix.

2. Give the "white glove" treatment to any lubricant leakage. Don't settle for blaming it on the instrumentation: be critical of the instrumentation as well.

3. On making a design change after development, qualification test, or both, don't rely on the designer's good intention and faith in the design fix, or on your intuition as an experienced engineer that it will work out — ask the machine. Answers will come from well-planned, honest testing. Don't be satisfied with token testing on the assumption that a particular design change has worked well in similar applications.

4. Don't let pressure from manufacturing and sales departments compromise testing. We all want to compromise or use our experienced judgment when faced with schedule pressure. Duress leads to snap decisions which are not as good as the carefully planned test program carried out by competent engineers.

From experience at Boeing, we have accumulated certain design criteria which can serve as guides to designers working with drive systems. They are as follows:

Nine design criteria

1. Safety can be designed initially into any pneumatic unit. Compromise is unnecessary. Turbine wheel designs 100% failsafe have been proved by manufacturers. And to obtain them several approaches have been used:

a. Bucket shedding.
b. Aerodynamic speed limiting.
c. Exhaust orifices.
d. Overspeed turbine wheel retaining nuts.

A design is adequate if the turbine wheel is incapable of bursting under any design condition, or allows burst with 100% containment.

2. Overspeed protection must be installed on the turbine wheel. No other location is acceptable.

3. Bearing failures are likely to occur, though infrequently, and failures can be hazardous. Designs have been developed which give considerable protection from severe damage. Failure detection with subsequent shutdown is available. Moreover, there are shutdown systems for protection in case of oil pressure loss.

4. Where two valves are used in a series (such as an on-off valve and a governing valve), a dual shutdown system should be used. Any reason for shutdown — deliberately by operator, overspeed, loss of oil, bearing failure — should cause both valves to snap shut.

5. Extreme care must be used when designing a hydromechanical system to insure that an uninterrupted oil flow is maintained in the drive during an "O" or negative "*G*" maneuver.

6. Before choosing magnesium for a housing material, give careful consideration to corrosion problems.

7. Increased efficiency at the expense of some added weight in some systems will buy increased airplane range. It should not be ignored.

8. Use nonmagnetic base materials for bearings in control loop systems.

9. Establish rigid processes and controls if welding or brazing is used in the manufacture of components. Hardware having brazed joints and located in the vicinity of the engine is subject to failures induced by vibration.

To Order Paper No. 128B . . .
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Suspension System Differences in the **COMPACTS** Are Tremendous

ALL six of the domestic cars and four typical foreign cars analyzed by Author Bond have independent front wheel suspension.

BUT there the similarities stop.

*

This second of three articles analyzing compact car designs, is a fact-filled, interpretive study of the "what" and "why" of 1960 "compact" front and rear suspension systems.

(First article of this series appeared last month in the April SAE Journal.

NEXT MONTH (June) will appear the final article in this series by Bond, entitled, "Are the Compacts of the World in a HORSEPOWER RACE?"

*

IN THIS article, as in the others of this series, Bond concentrates on the analysis of the six domestic compacts: Corvair, Falcon, Lark, Rambler A and B, and Valiant, and four typical foreign cars coming within the accepted definition of a compact (100-110-in. wheelbase). The foreign cars are: Jaguar 3.8, Fiat 2100, Mercedes 220, and Peugeot 403.

Based on paper by

John R. Bond

Publisher, Road & Truck Magazine

THE six domestic compacts and the four foreign cars being analyzed all have independent front suspension — but, apart from that, the differences in the suspensions are tremendous. (Statistical data on the suspensions for the domestic compacts are given in Tables 1 and 2.)

The Corvair uses a conventional short-and-long-arm, coil-type front suspension, but the unit is a complete subassembly, a practice borrowed from many years of prior experience. However, the earlier Chevrolets (as far back as 1934) bolted the cross-member-with-suspension directly to the frame, whereas the Corvair uses large rubber insulators. This gives shock isolation in depth at some cost in weight and/or "frame" rigidity. It looks very good from a service standpoint.

The Falcon independent front suspension is also of the sla-coil type, but its spring is mounted most unusually — just above the upper arm. (See SAE Journal, April, 1960, p. 38.) Since this type of mounting could put severe cocking stresses into the spring, the seat at the arm is arranged to pivot, so insuring relatively straightline action. The Falcon has the highest roll center of any U. S. car: 2.5 in.

The Valiant front suspension is very similar to, but smaller than, the parent firm's sla system with

Table 1
Front Suspension Details

	Tire Size	Spring Type	Wheel Rate, lb/in.	Oscil-lations/Min	Roll Rate, lb/in.	Roll Bar	Anti-dive
Corvair	6.50-13	Coil	86	62	182	No	45%
Falcon	6.00-13	Coil	80	70	260	Yes	35%
Valiant	6.50-13	Bar	105	70	232	No	70%
Lark 6	5.90-15	Coil	67	57	157	Optional	No
Rambler A	5.90-15	Coil	109	72	—	No	No
Rambler B	6.40-15	Coil	83	68	—	No	No

Table 2
Rear Suspension Details

	Spring Type	Width × Length, in.	Wheel Rate, lb/in.	Oscil-lations per Min	Roll Rate, lb/in.	Roll Dis-tribution, % front/ % rear
Corvair	Coil	—	192	66	293	38/62
Falcon	Leaf	2.0 × 50	94	82	160	62/38
Valiant	Leaf	2.5 × 55	125	69	260	48/52
Lark 6	Leaf	2.5 × 51	97	83	185	46/54
Rambler A	Leaf	1.75 × 45	100	74	—	—
Rambler B	Coil	—	96	67	—	—

torsion bars. An interesting deviation is placing the adjustment for standing height at the drive end of the bar, rather than at the anchorage. This was done for ease of access and lessened corrosion attack.

The Lark system is more conventional and its distinguishing feature is the time-tried Studebaker knuckle support with one needle bearing, one bronze bushing, and one ball thrust bearing at each steering pivot. Here we also find the only application of a variable-rate coil spring via a change in helix angle, which progressively puts coils out of action.

Both Ramblers continue with their own independent front suspension system, in which the coil spring seats on a stamped steel pan concentric with the kingpin axis. Thus, the spring rate is also the wheel ride rate and no swivel-seat is necessary. This location also gives very good antiroll resistance.

The French Peugeot (Fig. 1) continues with its tranverse leaf spring acting as lower wishbones. The upper wishbone pivots are piston-type shock dampers. The leaf spring has double wrapped eyes, 9 leaves of 2.76-in. width, and measures 43.4 in. long, center to center. The designed load is 1300 lb; its rate is 272 lb per in., equivalent to a wheel ride rate of about 136 lb per in.

Jaguar (Fig. 2) and Mercedes (Fig. 3) both use conventional sla-coil arrangements. The Jaguar and Mercedes assemblies are in a unit with the front cross-member, but only the Mercedes uses rubber insulators between the member and the chassis-frame. The latest Jaguar sedans have raised the front roll center to 3.25 in. above the ground for better handling and cornering power. Fiat uses a system rather similar to that of the Valiant, as shown in Fig. 4.

At the rear we also find remarkable variations, though conventional leaf springs with Hotchkiss drive predominate. As is well known, the Corvair uses an independent setup with single swinging arms on each side and arranged with diagonal axis.

Both Falcon and Valiant use asymmetric leaf springs, the front/rear dimensions being 22/28 in. in the Ford product and more extreme — at 20/35 in. in Plymouth's compact. The Falcon's front mounting uses a 2-in. rubber bushing, as does the new Comet in which the entire Falcon rear-axle and spring assembly has been moved aft by 4.5 in. to get a longer wheelbase. Incidentally, the Comet's ride is definitely softer than that of the Falcon. The published front/rear oscillations per minute figures are: Falcon 70/82, Comet 60/70. This is more difference than can be attributed to the 90-lb extra weight of the Comet.

The Peugeot uses torque tube drive with coil springs in a layout very similar to that of the Rambler B. Fiat's rear suspension is similar to one they have used for 10 years with a quarter-elliptic spring used to anchor the rear axle and coils serving as the springing medium (Fig. 5). Mercedes' low-pivot swing axle is well known. Fig. 6 shows the latest design. The central or "compensating" spring has been adopted to allow lower ride rates without bot-

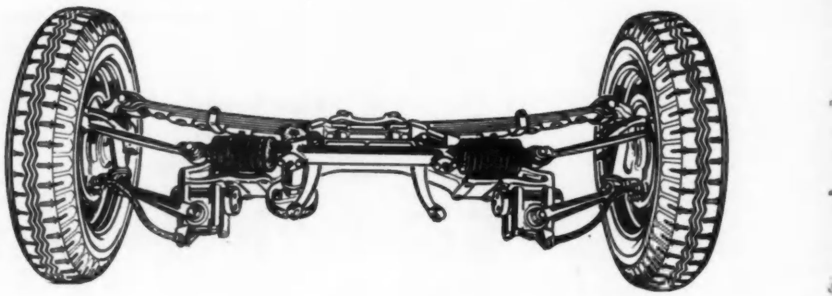

Fig. 1 — **Peugeot** independent front suspension.

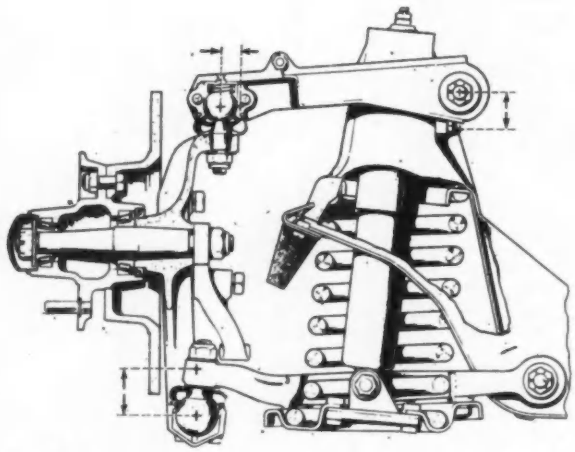

Fig. 2 — **Jaguar** independent front suspension. Drawing shows changes made to raise roll center from ground level to point 3.25 in. above the ground. Plus marks (+) show location of pivot points on earlier models, before change.

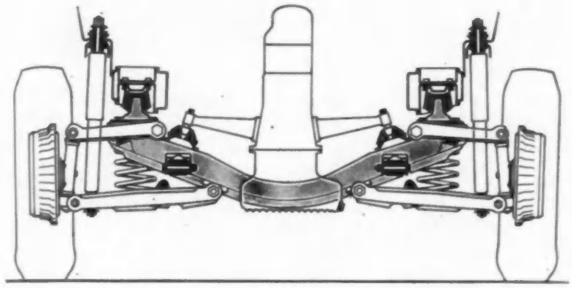

Fig. 3 — **Mercedes** independent front suspension.

Suspension System Differences in the Compacts are TREMENDOUS

. . . continued

toming, and these cars (the 220, 220-S and 220-SE) now exhibit a slight understeer at all times.

Jaguar's 2.4, 3.4, and 3.8 sedans have the most unusual rear suspension of all (Fig. 7) — by cantilevered leaf springs. Rubber is used profusely and the riding qualities are truly remarkable. Obviously, this arrangement ties in well with unit construction.

Although the Swedish Saab is too small to be classified as a compact (its wheelbase is 97.9 in.), it has a most unusual rear suspension, as shown in Fig. 8. This being a front wheel drive car, there is a "solid" rear axle. This takes the form of a curved tube, anchored at the center by a rubber bushing. Links on each side locate the wheels and in roll the geometry is such that the axle tube tends to be bent. This sets up extra roll resistance, yet allows moderate wheel ride rates. In some respects, this approach is very nearly the opposite of the Mercedes-Benz compensating spring.

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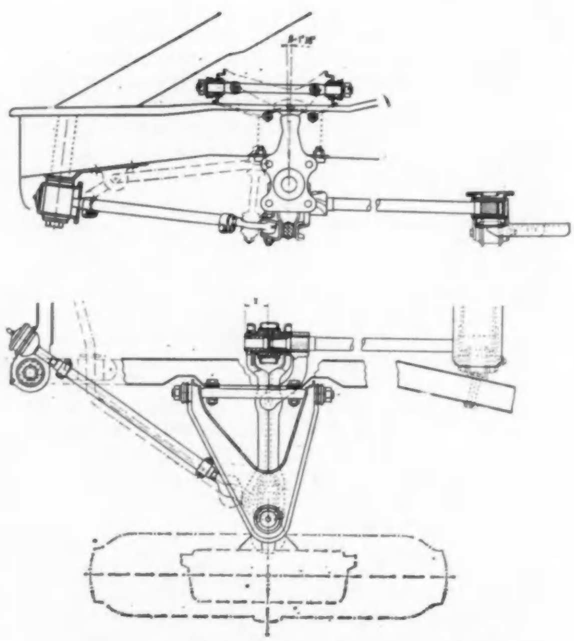


Fig. 4 — **Fiat** independent front suspension.

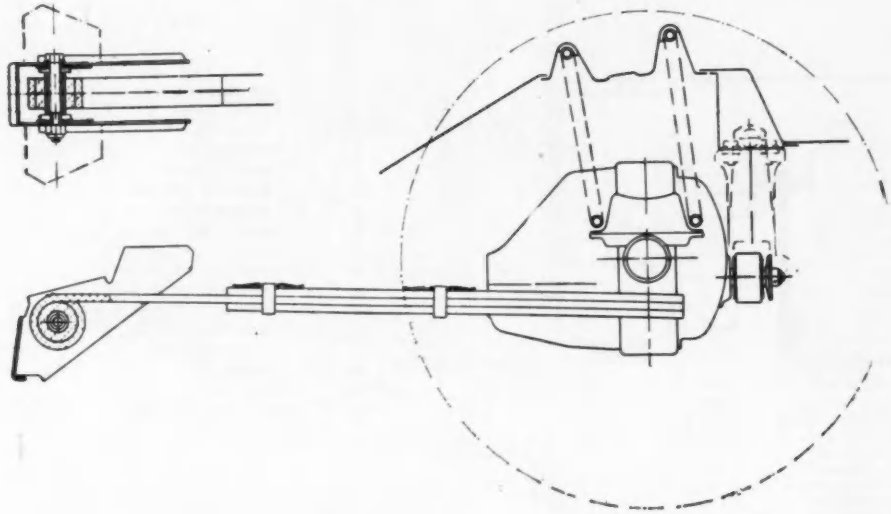


Fig. 5 — **Fiat** rear suspension.

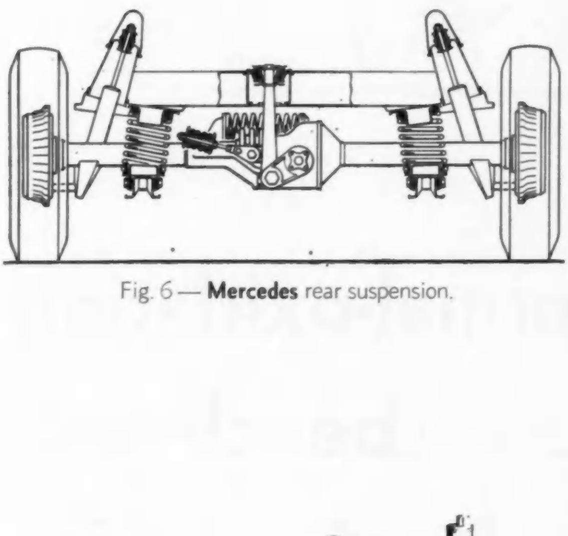


Fig. 6 — **Mercedes** rear suspension.

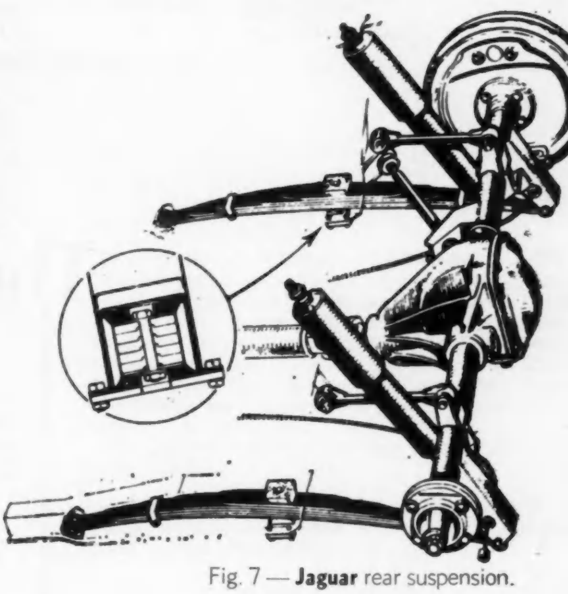


Fig. 7 — **Jaguar** rear suspension.

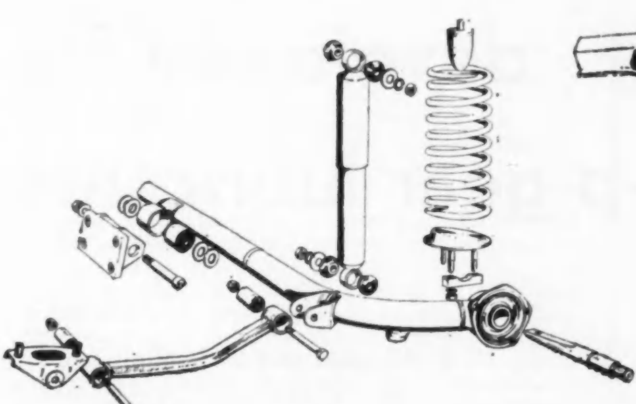


Fig. 8 — **Saab** rear suspension.

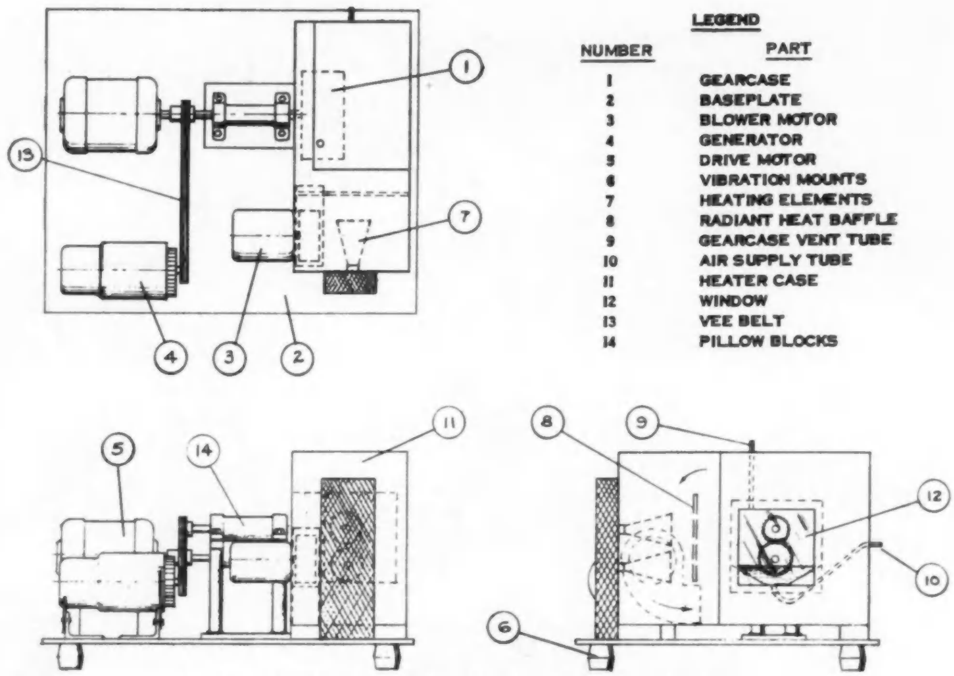


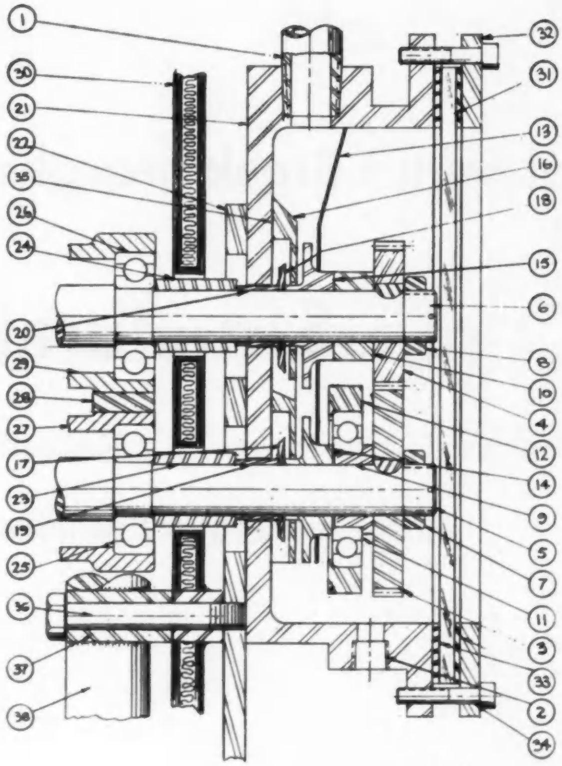
Fig. 1 — **Sketch of thermal-oxidation stability test apparatus.**

Thermal-oxidation bench test developed for e-p gear lubricants

Based on paper by

N. T. Meckel and R. D. Quillian, Jr.

Ordnance Fuels & Lubricants Research Laboratory
Southwest Research Institute



LEGEND

NUMBER	PART
1	VENT TUBE
2	CASE AIR INLET
3	TEST GEAR, 50 TEETH
4	TEST GEAR, 34 TEETH
5	GEAR SHAFT, DRIVING
6	GEAR SHAFT, DRIVEN
7	GEAR RETAINING NUT, RH THREAD
8	GEAR RETAINING NUT, LH THREAD
9	TEST BEARING BUSHING
10	SPACER BUSHING
11	TEST BEARING
12	TEST BEARING CLAMP
13	BAFFLE PLATE
14	OUTER SLINGER, LOWER
15	OUTER SLINGER, UPPER
16	SEAL PLATE
17	INNER SLINGER, LOWER
18	INNER SLINGER, UPPER
19	SLINGER BUSHING, LOWER
20	SLINGER BUSHING, UPPER
21	GEARCASE
22	GEARCASE SUPPORT
23	RETAINER BUSHING, LOWER
24	RETAINER BUSHING, UPPER
25	PILLOW BLOCK BEARING, LOWER
26	PILLOW BLOCK BEARING, UPPER
27	PILLOW BLOCK, LOWER
28	SPACER, PILLOW BLOCK
29	PILLOW BLOCK, UPPER
30	HEATER CASE
31	WINDOW, GEARCASE
32	RETAINER, GEARCASE WINDOW
33	GASKETS, GEARCASE WINDOW, 1/16" THICK
34	CAP SCREW, GEARCASE WINDOW RETAINER
35	GASKET, SEAL PLATE
36	BOLT, CASE SUPPORT TO PILLOW BLOCK SUPPORT
37	BOLT TUBE
38	PILLOW BLOCK SUPPORT

Fig. 2 — **Cross-section of gearcase.**

THERMAL-oxidation stability of extreme-pressure lubricants (conforming to MIL-L-002105A spec) can now be evaluated in the laboratory by means of a test that correlates well with field service results.

The new bench test procedure replaces the previously used "glassware" tests, which proved unsatisfactory because the data it produced were inconsistent and not comparable with field results. The new thermal-oxidation stability test is more satisfactory because it more nearly simulates conditions and phenomena encountered in the field.

A sketch of the apparatus used for this test is shown in Fig. 1. Heart of the apparatus is the gearcase, shown in cross-section in Fig. 2.

Specifically, the important conditions of operation of actual transfer cases and differentials that the new technique was designed to duplicate more closely than do the "glassware" tests are:

1. Gear operation: The service unit involves the operation of gears, which subjects the lubricant on the working teeth to shear stress.

2. Gearcase heating due to friction of gears and bearings and internal friction of the lubricant, rather than from an external heat source. The gear friction is undoubtedly the largest source of heat and the working gear teeth are the hottest parts of the system. The oil is subjected to shear stress on

THE THERMAL-OXIDATION STABILITY TEST discussed here marks the last of a number of tests developed for determining the performance of extreme-pressure gear lubricants to meet the new military spec MIL-L-002105A (which was issued in December 1958, as a revision of MIL-L-2105). In addition to the thermal-oxidation stability test, **the new spec includes: high torque tests, high-speed and shock tests, and a moisture corrosion test.**

The first two tests have already been covered in SAE Journal as follows:

- **The L-37 technique**, which combines in a single test both high-speed and high-torque requirements (SAE Journal, December 1957, p. 32).

- **The L-42 technique**, which measures antiscoring properties of gear lubricants under high-speed and shock-loading conditions (SAE Journal, December 1958, pp. 46–48).

The new specification has much more severe requirements than its predecessor because, in the past few years, **increased speeds and loads in gearing of commercial and military automotive equipment** have brought a general increase in severity with respect to gear scoring, wear, and higher operating temperatures for the lubricant.

The laboratory and full-scale field programs were conducted by the **Ordnance Corps and various industry laboratories, in cooperation with CRC.**

the working teeth, which is the highest temperature region of the system.

3. Metals may act as oxidation catalysts in the full-size units in ways that differ from those in "glassware" tests as follows:

(1) The gear teeth and bearing load-carrying surfaces, having direct metal-to-metal contact, do not build up the same type of deposits as those found on the quiescent catalysts used for "glassware" tests.

(2) The catalyst metals usually are subjected to continuous or intermittent oil throw-off or flow rather than complete immersion, as is common with bench test procedures.

Oxygen and Temperature Effects . . .

FOLLOWING development of the test technique discussed here, it was used to investigate the thermal-oxidative degradation phenomena of gear lubricants.

The effect of oxygen was studied by conducting tests with oxygen, air, and various inert gases while keeping the test oil temperature constant. The temperature effects were determined by conducting tests at various temperatures while metering air and other gases into the gearcase.

The results of this study showed that:

- Oxygen, air, helium, and nitrogen atmospheres made little, if any difference in the viscosity and oxygenated material content of finished oils.
- Oxidation of base oils was accelerated by oxygen and retarded by nitrogen and helium atmospheres.
- Effect of gear meshing appeared to influence thermal-oxidation degradation significantly, although the reaction was not catalyzed by the steel test gears or copper.
- Deposition was influenced by oil composition and test conditions and did not appear to correlate with used oil properties.
- Polymerization had a strong influence on the degradation process.
- Certain additives and a number of typical additive components do inhibit the thermal-oxidation process.

(3) The wear particles are accumulated in the lubricant at varying rates, depending on the characteristics of the oil and other factors. Whereas some bench test procedures specify a certain amount of metal powder of rather uniform particle size to be added at the beginning of the test, the wear particles from actual units have different surface finishes, coatings, and probably vary considerably in particle size distribution and in surface-to-volume ratio.

4. More thorough mixing of air in the oil appears to occur in the service units, since most test procedures rely on bubbling or stirring. The oil, in the form of small droplets or spray at an extremely high surface-to-volume ratio, is exposed to the atmosphere inside the gearcase during actual operation.

To Order Paper No. T38 . . .
. . . on which this article is based, turn to page 6.

Breakthroughs

Structural

Recent

suggests greater

Based on paper by

A. F. Thomson and A. F. Martin

Minnesota Mining & Manufacturing Co.

STRUCTURAL ADHESIVES are being used successfully in a variety of automotive applications. Their many desirable properties, however, should lead to even greater use in the future.

High solids pastes are currently being used to bond stiffeners to exterior body surfaces. They are bonding to oily metal, and the curing is being accomplished during the paint-curing cycle. Products of this nature in production use attain strengths on the order of 200 psi in tensile. In addition, they are satisfactory as to cold shock, dry-heat aging, water resistance, and other passenger-car environmental conditions. These pastes also are finding utility as an adhesive-sealer in combination with hemming operations. Here, spot welding is used to position the two halves of the shell, with the adhesive paste in the folded metal providing the structural bond. Again the bond is to oily metal with the curing accomplished in the paint ovens.

The bonding of a bracket to an exposed portion of the automobile was recently engineered using a film structural adhesive. The major economic saving was represented by the elimination of metal finishing of the normal spot-weld blemishes. This saving was insufficient, however, to attain the required break-even point and the use of structural bonding was cancelled.

The future significance of structural adhesives in automobile manufacture has aroused considerable

signify bright future for

Adhesives in Cars

successful use of structural adhesives in autos

application in the future.

thinking on the part of adhesive manufacturers as well as automobile manufacturers. Structural adhesives are particularly adapted to compete with present bonding methods for nonferrous materials. In some cases they are the only sensible joining method. The light-weight nonferrous materials are rapidly becoming an integral part of the automobile and will bring structural adhesives with them.

The use of adhesives permit the use of lighter gage metals since the load can be spread over a larger joining area. The adhesives also provide the means of joining dissimilar metals without the hazard of galvanic action. The fact that joining with adhesives forms a seal as well as a bond should not be overlooked. Think of the headaches which will be eliminated when it is no longer necessary to gunk up the drip rail and the trunk gutter with sealer. This can be extended to the cowl and floor seams. No more asphalt to track all over the shop. This is a reality not too far in the future.

Exterior-coach joint headaches will become a thing of the past. Visualize a unitized top in which the present system of stiffeners, insulation pads, and headlining is replaced with a structurally bonded honeycomb. The core materials could be aluminum, paper, or some other suitable material while the face material could be of reinforced plastic, a decorative laminate, or some other suitable decorative material. Such an assembly would have strength and insulation value with a considerable saving in space.

The future of adhesives is not limited by any means to the automobile body. In fact the use of adhesives in the powerplant and its auxiliaries will likely cause the most immediate excitement. Here the use of adhesives would permit designs previously unattainable. Automotive components have been created using adhesives which have given performance in excess of present designs.

Adhesives shine in vibration tests

A vibrational fatigue test is usually run on structural adhesives. In this test a 3/8 sq in. overlap assembly is loaded in tensile at 600 psi and then vibrated between 60–600 psi at a frequency of 3600 cycles per min. Stress is so applied and amplitude of vibration is such that the bond is always under tension, never in compression. The standard structural adhesive will withstand more than 10,000,000 cycles at room temperature. It is interesting to note that at – 67 F the aluminum will fatigue fail in this test. This energy absorption or damping property accounts for the superior fatigue life of an adhesive assembly. In one laboratory test, studying joint fatigue life for the B-36 design, comparative fatigue lives on identical detail parts were:

Method	Cycles to Fail
Spot-welded joints	12,000,000
Riveted joints	18,000,000
Adhesive-bonded joints	240,000,000

A 1959 ASTM subcommittee reviewing fatigue failure experiences in aircraft found not one instance of an adhesive bond failure due to fatigue. However, there were instances of metal fatigue under the same conditions.

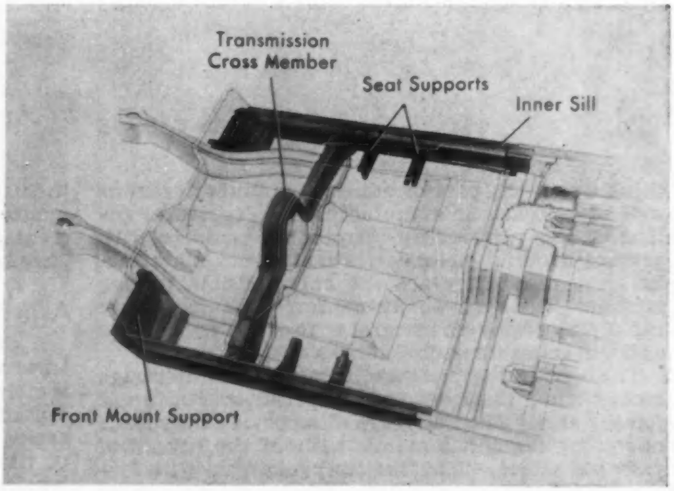
To Order Paper No. 145A . . .
. . . on which this article is based, turn to page 6.

Features of Chrysler's New

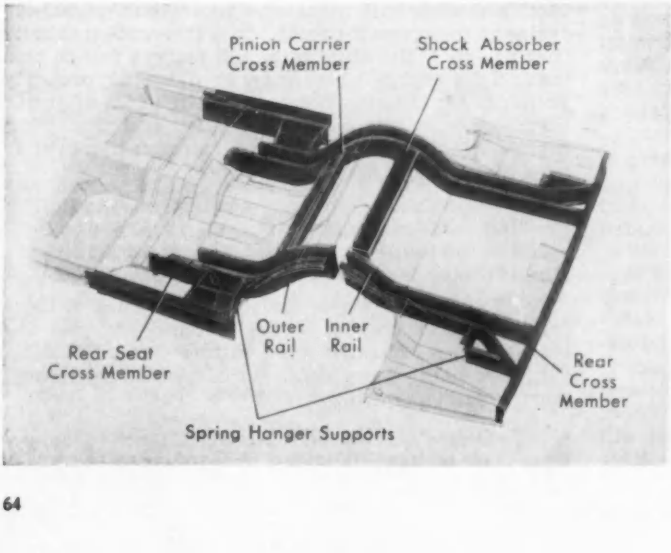
include . . .

Based on report by

J. W. Shank and R. H. Kushler
Chrysler Corp.

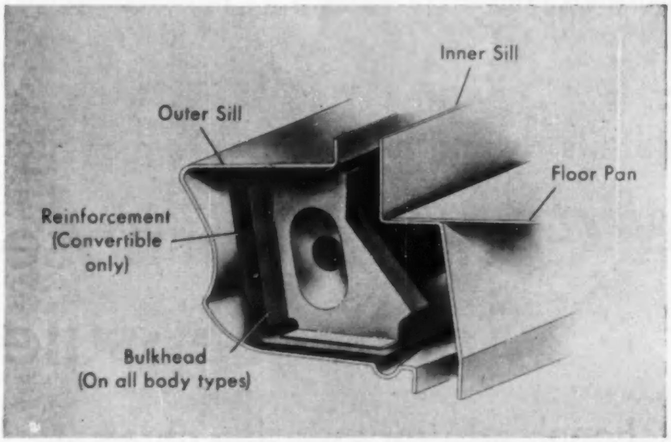


COMPLETE FRONT UNDERBODY ASSEMBLY of two-piece, "unibody" structure carries front suspension and power unit. Main members include right and left inner sills, front structural mounting reinforcements, and transmission cross-member. Inner sill subassemblies, which include front mounts and seat supports, are added to the hat-section cross-member that opens downward, forming the H assembly to which is added the front floor pan. All welding is done automatically with identical weld pattern for every make and model. Only physical differences are: (1) variations in inner sill gage for differing wheelbases and, (2) two front mounting reinforcements to give maximum span between cross-member and front mounts on longer wheelbase cars.



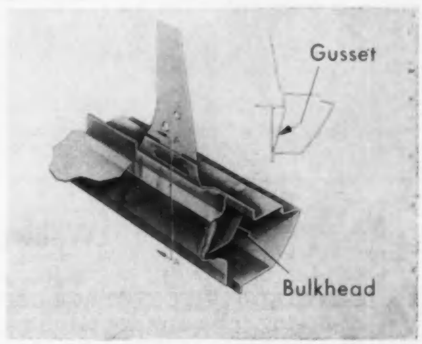
REAR UNDERBODY ASSEMBLY carries rear suspension. Main members include rear longitudinals (rails), front and rear spring hanger supports, and four cross-members each serving a basic structural function as well as providing torsional rigidity. Rails are made in two halves, an outer and inner Z-section member, welded along bottom surface of resulting hat-section. Splitting eliminates severe draw problem and simplifies welding of spring hanger supports to rail outer surface. Z-section rear cross-member supports bumper impact and jacking loads, and transmits rear spring loads. Pinion cross-member provides rear axle carrier nose control. Rear seat cross-member provides main tie between rear and front underbody assemblies and is, therefore, a torsional member.

"Unibody" Construction

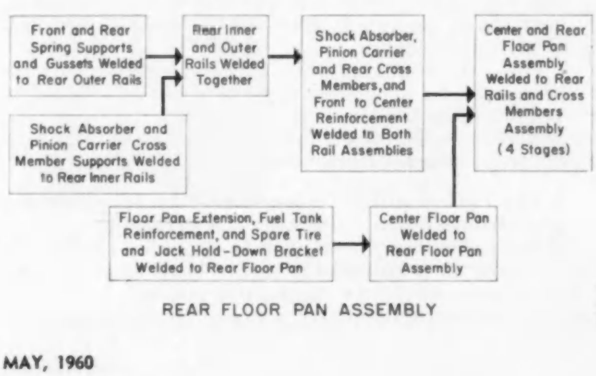


INNER SILL is made of 0.060, 0.075, or 0.090 gage stock, depending on wheelbase length. Outer sill is 0.075 stock. Thus, one basic sill section serves all wheelbases and models. A reinforcement is added for convertibles and bulkheads are placed in the sills of all models to distribute input loads and maintain section shape. Bulkheads are located at the 4-door hardtop center pillar, rear suspension hanger bracket, and transmission cross-member.

CENTER PILLAR inner member ties to a gusset which nests between the inner and outer sills. Bulkheads and sill outer reinforcements distribute the pillar loads into the sill without localized buckling. By using a good joint between the pillar and sill, advantage was taken of torsional rigidity and end fixity required for normal body loads such that no additional structure is needed to withstand rear door hinge and front door slam loads. Note absence of an inside brace.



FRONT FLOOR PAN ASSEMBLY



REAR FLOOR PAN ASSEMBLY

UNDERSTRUCTURE ASSEMBLY FLOW CHART.

To Order Paper No. 137A . . .
. . . on which this article is based, turn to page 6.

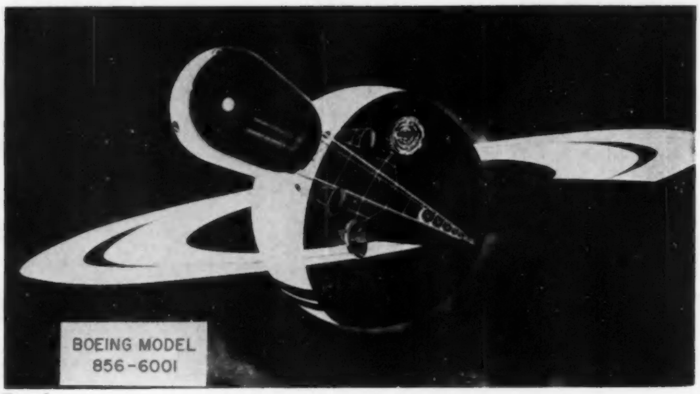


Fig. 1

MISSIONS PLANNED for special types of the Boeing general-purpose space capsule described in this article include probing deep outer space in out-of-elliptic orbits, planetary explorations, and other outer-space explorations.

Boeing details design and assembly plans for

A General-Purpose Space Capsule

Four basic, though arbitrary, design parameters selected. Outer space assembly planned

Based on paper by

Wellwood E. Beall

Boeing Airplane Co.

A GENERAL-PURPOSE SPACE CAPSULE (Fig. 1), as Boeing engineers are planning it, can best be developed in terms of the following ground rules:

1. The vehicle is to be assembled in a geocentric orbit.
2. It will use a low-thrust, nuclear-powered propulsion system.
3. There will be no artifical gravity. This vehicle will seek weight optimization through simplicity and volumetric efficiency.
4. There will be provision for dual reliability in encapsulation.

The choice of these four arbitrary parameters has, with associated considerations, determined the general configuration shown in Fig. 2. Reasoning behind selection of these four parameters runs something like this:

1. . . . The vehicle is to be assembled in a geocentric orbit. Vehicles both partly and wholly assembled in space allow the highest degree of weight optimization because it is then not mandatory to design all or portions of the structure on the basis of a short burst of high acceleration.

For interplanetary work, where the vehicle is expected to be propelled beyond a geocentric orbit, weight optimization will remain the most critical design objective until the advent of some radically different means of propulsion.

2. The vehicle will use a low-thrust nuclear-powered propulsion system. Because this particular study is basically a vehicle design, it is concerned primarily with overall performance rather than with detailed considerations of the propulsion system.

A low acceleration program was chosen in order to

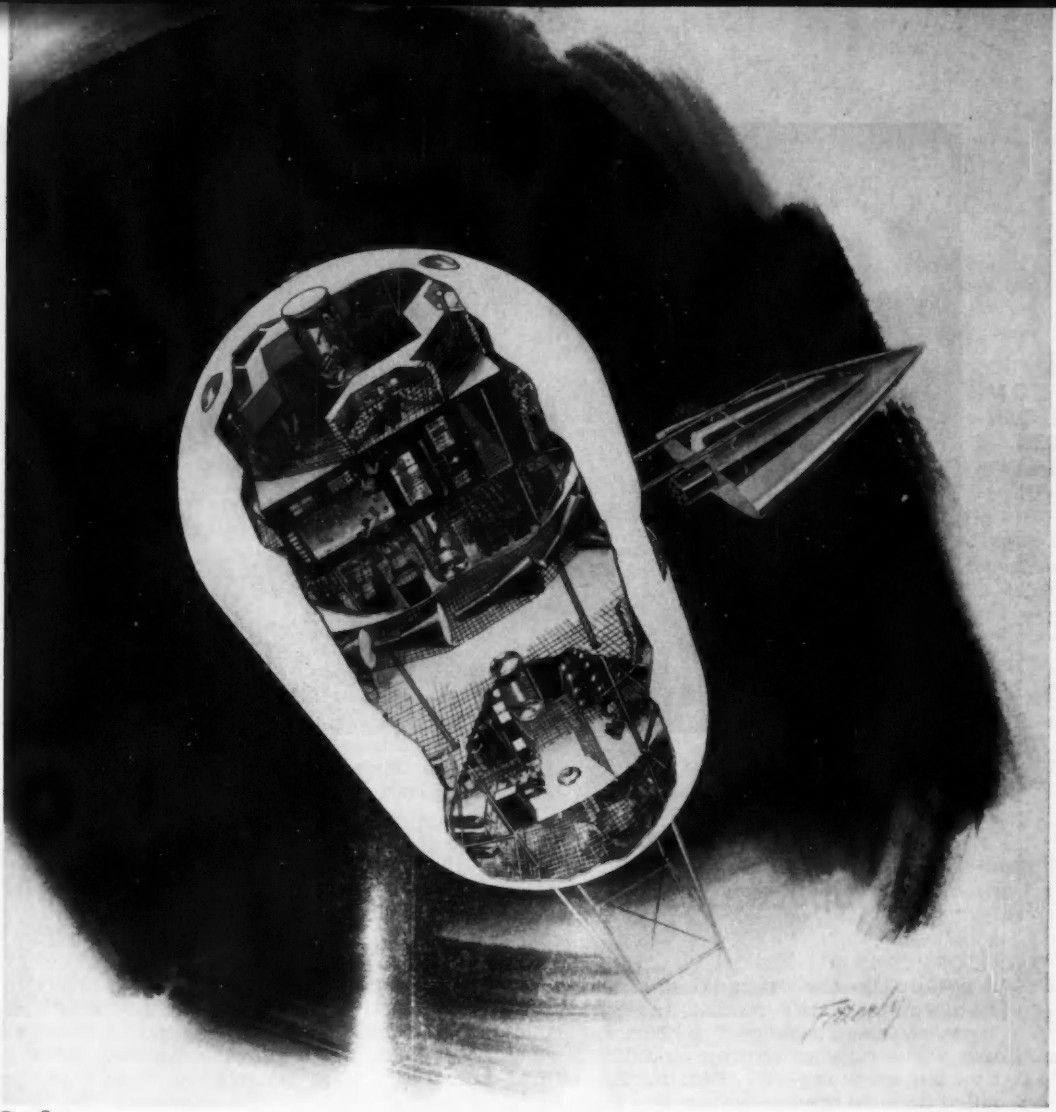


Fig. 2

PROPOSED GENERAL-PURPOSE SPACE CAPSULE, showing plasmajet system reactor, and liquid-hydrogen tanks at the extremity of a boom in order to minimize the weight of shadow shielding required to protect the space capsule.

BEALL

WELLWOOD E. BEALL, now Boeing's senior vice-president, has been designing and researching advanced aerospacecraft for many years. Each of the important design projects which he has led carried an "in-the-future" tag at the time he started work on it. These projects have included such famous craft as the Boeing Stratoliners, Flying Fortresses, Superfortresses, Stratocruisers, Stratofreighters, Stratojets, the Boeing 707 Jet Transport, and — in recent years — guided missiles. . . . Now Beall is working on the Dyna Soar space-vehicle project — a part of which this article is concerned with.

Discussing relationships between aircraft and spacecraft recently, Beall said: "Actually the aircraft and the missile industries are synonymous. . . . For instance, Boeing research leading to the Dyna Soar boost-glide concept antedates that program by several years."

Beall was an SAE Director in 1951 and 1952. He discussed the full range of the Dyna Soar project at SAE's Aeronautic Meeting in New York last month.

Fig. 3 Suggested method for **ACCOMPLISHING CONSTRUCTION** of a space capsule in a geo-orbital position.

A General-Purpose Space Capsule

. . . continued

examine weight optimization to the maximum degree. Shown is a plasmajet system, reactor, and liquid-hydrogen tanks at the extremity of a boom in order to minimize the weight of shadow shielding required to protect the space capsule. Because this vehicle is not called upon to operate within any atmosphere, shielding at the capsule wall is limited to the values required for protection against spaceborne radiation.

Atmospheric scattering is not a problem and the reactor is not particularly fast. The boom structure considered here has been the subject of applied research in the Boeing structures staff. Thin-wall, axially corrugated members produce extremely lightweight structures for these low-load applications while providing the necessary surface area and plumbing for cooling the working fluid of the nuclear-power system.

3. There will be no artificial gravity. This particular vehicle again seeks weight optimization through simplicity and volumetric efficiency. Artificial gravity arrangements tend toward elongated, disc-shaped, or toroidal volumes, all of which have higher ratios of surface area to unit volume than the sphere or a volume resembling a sphere. Because surface-area shielding is a critical weight item, spheroids quickly emerge as leading candidates.

In addition, a zero-gravity, attitude-stabilized vehicle avoids the necessity of maintaining certain major components in a fixed celestial attitude while rotating the remainder. It thus avoids additional mechanical, structural, and power requirements, all involving additional weight, complexity, and cost.

One way an astronaut might schedule his exercise and simultaneously avoid long-term exposure to weightlessness would be simply to walk around the inside of this 40-ft diameter vehicle as in a squirrel cage for 5 min in every hour. At a brisk walk of 4 mph, he will be pulling 1/20 of an Earth gravity. At a trot he can approach half a gravity for considerable periods of time depending on his wind. Of course, he would either have to be accompanied by a companion going the other way for a number of turns in proportion to his relative mass or do an equal number of turns in both directions himself in order not to leave the vehicle in a different attitude than when he began.

4. There will be provision for dual reliability in encapsulation. All interplanetary missions for the type of system selected will involve years of continuous service. The shortest time for a Martian round trip by minimum energy orbits is 2.5 years. Permanent Trojan-point stations involve indefinite life.

Second only to propulsion for the round trip is the function of maintaining the human occupants in an atmosphere for the mission duration. Many detailed trade studies will be required before the best methods of accomplishing this can be stated.

One promising initial approach is the concept of dual reliability. Here we have two separate pressure vessels separated by an air lock. Each vessel is composed of a 20-ft radius hemisphere joined to an ellipsoid (or cassinian ovoid) with a semiminor axis of 10 ft. The two vessels are joined by a cylindrical member, which forms the housing for the central air lock or hangar deck. The air lock is 14 ft high at the vehicle centerline, so the overall capsule length is 74 ft. Shielding and insulation are applied only to the outer shell so the two ellipsoidal members need only serve as pressure shells. When the air lock is closed and sealed, the entire capsule may be pressur-

ized so the ellipsoids are then inactive. Damage control of the pressure vessel is provided in two ways. Each vessel will house the entire crew complement easily while space-suited specialists are making repairs on the other vessel, and no internal stores or installations are located nearer than 18 in. to the outer wall so no time-consuming hauling or disassembly need hinder immediate remedial action.

Each general purpose space-capsule will have three levels. There is no up or down except during powered flight. But, for the sake of clarity, the control level has been called the top. The seven levels are:

1. Control.
2. Astrogation.
3. Function stores.
4. Hangar deck.
5. Living.
6. Rest and recreation.
7. Biophysical stores.

Nylon nets are adequate to separate levels because the vehicle is in a weightless state except during powered flight. Communication between vessels is by two tubes that are open at both ends unless one vessel is evacuated for repair. In that event the two tubes serve as air locks. Each vessel has an air lock to space and an air lock to the hangar deck. For a vehicle of the size shown here, the crew complement is 20 men.

This vehicle is essentially a rubber design in that it can be expanded or compressed for differing mission requirements. It does, however, seem to embody a highly desirable set of attributes in the light of our present concept of space travel. It takes advantage of many techniques for controlling weight, and consequently cost, while providing for crew safety and mission reliability.

Building the space capsule

A suggested method of accomplishing the construction of the space capsule in a geo-orbital position is shown in Fig. 3.

For a weight-optimization vehicle that is to be propelled into deep space on inteplanetary missions, the desirability of carrying materials to orbit in small hardy packages and building the structure there becomes apparent. With proper planning and rehearsal the crew on this job should be able to complete at least one of the basic pressure vessels, from which to operate, in about 6 months. Until then they could work inside a plastic balloon without the hindrance of space suits. The life of such a balloon is, of course, a matter of considerable uncertainty.

A proposal is illustrated here that a double wall would contain a gaseous-chemical indicator with the characteristic of a chromatic change in the presence of some constituent of the atmosphere on the inside. Thus meteoroid penetrations or other leaks could be detected and repaired.

It is quite obvious that this and other proposals for similar purposes all entail much research, both theoretical and applied. All the trades involved will not be clear until the body of specific data on the space environment is enlarged considerably.

To Order Paper No. 165A . . .
. . . on which this article is based, turn to page 6.

Radiotracers Aid Study of *Cylinder wear*

Irradiation of selected sections of large engine parts now allows the radiotracer method of determining wear to be extended to large engine cylinders. Long used for piston-ring wear measurements, the technique now provides accurate results quickly and economically for the more important cylinder wear.

Based on paper by
W. C. Arnold and V. T. Stonehocker,
Fairbanks, Morse & Co.
and **W. J. Braun and D. N. Sunderman,**
Battelle Memorial Institute

RELIABLE information about engine wear never before obtainable can now be determined quickly, easily, and economically, thanks to recent advances in nuclear reactors and new irradiation techniques. These make possible the irradiation of selected sections of large specimens, such as cylinder liners.

Although radiotracer techniques have been used for some years to measure piston-ring wear, until recently it was not possible to apply this method to larger parts, such as cylinders. Unfortunately, ring wear data seems to bear little correlation to wear rates of cylinder liners . . . and cylinder wear is more important than ring wear because cylinders cost more to replace.

With the new techniques, the effect on cylinder wear of starting, idling, and cold temperature operation; sudden cold changes; speed; torque; and other variables can easily be determined. Simultaneous data can be obtained on rings and cylinders and other wearing parts of the engine through the use of different isotopes and pulse height analysis. Local areas can be monitored through selective irradiation of the cylinder in conjunction with the pulse height analysis.

Various phases of the new technique are:

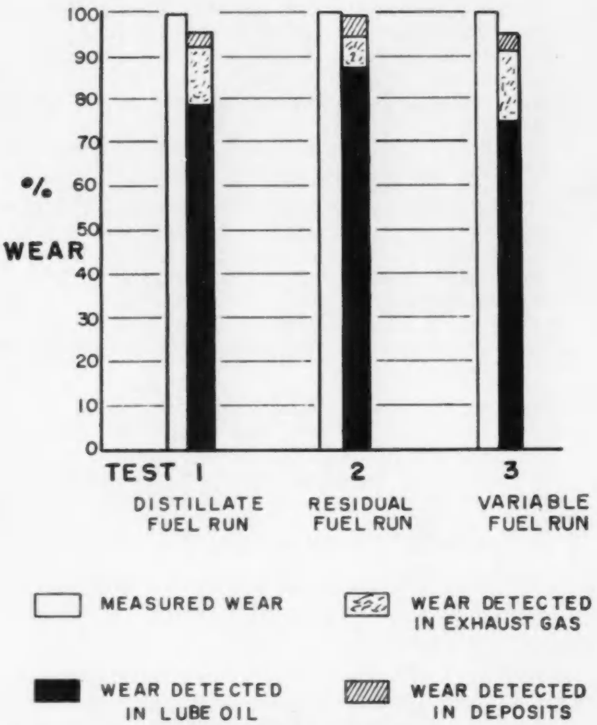
- Irradiation of selected areas of the cylinder liner.
- Handling and installation of the radioactive liner in a diesel engine.
- Radioassey procedures for qualitative and quantitative determinations of cylinder wear.

Irradiation techniques

The cylinder liner selected for irradiation was 42 in. long, weighed 160 lb, and was designed for the Fairbanks, Morse, $8\frac{1}{8} \times 10$-in. opposed-piston diesel engine.

The liner was irradiated at the inner-dead-center position of the compression-ring travel because this

New technique gives accurate results . . .



Wear measurements obtained by radiotracer technique compared with those obtained directly.

AN INDICATION of the accuracy of the detection technique and the distribution of the debris is given in the illustration at the left.

Actually, the **percentage of debris** detected in the oil or exhaust gas varies considerably, depending on operating conditions.

During test No. 3, for example, **exhaust debris detection varied from 10 to 50%** of the total.

The data from test No. 1 (305 hr) and test No. 2 (210 hr out of a total test time of 322 hr) were **statistically analyzed for standard deviations.**

The **reliability of the curves** representing these data were determined by employing the statistical methods described by Youden.

The **deviation** of test No. 1 was found to be 9.5% and test No. 2, 5.4%.

is the area of maximum wear in the Fairbanks, Morse opposed-piston-engine cylinders.

This was accomplished by providing the liner with an external shield of cadmium and an internal shield of boral alloy, as shown in Fig. 1. A 1½-in. wide unshielded target band is visible at the position corresponding to the contact zone of the top two compression rings of the lower piston when at its inner-dead-center position. The wires visible about the circumference of that zone are aluminum-cobalt dosimeter wires used for recording the integrated thermal neutron flux falling on the target zone.

The shielded cylinder liner was installed in the watertight aluminum capsule shown in Fig. 2. The aluminum tube, later removed, was used to pressurize the capsule with helium during irradiation. This gas prevented water from entering the capsule if it leaked during irradiation. Since helium does not become radioactive, the hazard to reactor personnel in case of capsule failure was minimized.

The helium-pressurized cylinder-liner capsule was irradiated for four weeks in a pool-type water-cooled and water-moderated reactor. Fig. 3 illustrates the placement of the capsule in the reactor and the drive mechanism that was employed to rotate the specimen at 1 rpm. Capsule rotation resulted in extremely even irradiation.

Following irradiation the liner was placed in a large diameter lead shield and de-encapsulated. Next, a small quantity of cylinder-liner metal filings radioactivated in shielded and unshielded areas of the liner were analyzed.

Substantial amounts of 300-day half-life manganese 54 was evenly distributed in both shielded and unshielded zones. That radioisotope was produced by fast or high-energy-neutron activation of iron 54. The amount of 45-day half-life iron 59 and 27-day half-life chromium 51 produced in the unshielded target zone was much less than had been anticipated because of the effect of neutron perturbation (a reduction in the thermal-energy flux reaching the unshielded target, because of the large amounts of cadmium and boron in the vicinity). In fact, perturbation resulted in about one-twentieth the anticipated thermal neutron activation of target zone metal.

Fig. 4 shows the gamma-ray spectra of target-

Cylinder wear

. . . continued

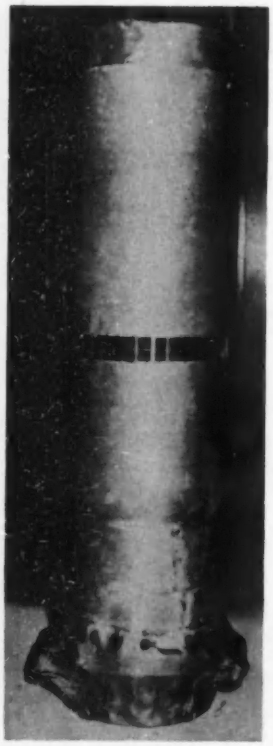


Fig. 1 — Cylinder liner with external shield of cadmium and internal shield of boral alloy.

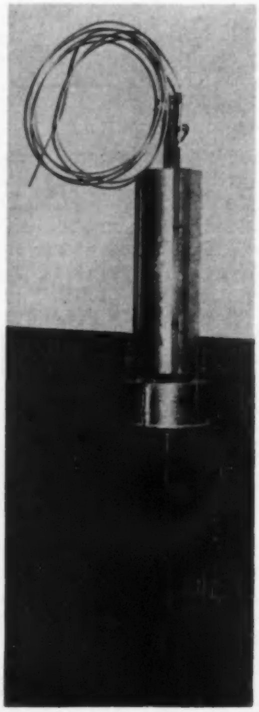


Fig. 2 — Shielded cylinder liner installed in watertight aluminum capsule, pressurized with helium.

zone irradiated metal. The characteristic gamma rays of iron 59, manganese 54, and chromium 51 are illustrated. The top curve was obtained 23 days after irradiation and the lower one at 195 days. The decay of the shorter half-life chromium 51 and iron 59 radioisotopes, with the emergence of long-life manganese 54 as the dominant radioactive specie is shown. Note that much less iron 59 and chromium 51 were initially produced in the shielded zones of the liner. A radioisotope spectra similar to that illustrated by the lower curve existed in the shielded zones of the liner immediately after irradiation.

The following evaluation was made of the radioactive cylinder liner.

1. The attempt to radioactivate a liner in a small, specific zone to a comparatively high level of specific radioactivity was successful to a limited extent. With the employment of elaborate radation detection equipment during analysis it would have been possible to discriminate wear occurring in that zone. However, it was not attempted in this program.

2. Manganese 54 was produced in useful quantities in the entire lower half of the liner. The 300-day half-life of that radioisotope resulted in a liner with a useful radioactive life of years, compared with that of months normally present in piston rings, which are normally activated in a manner that produces shorter-life iron 59 and chromium 51.

3. The desirability for capsule rotation was confirmed by the evenly radioactivated cylinder liner.

Handling and installation techniques

Studies performed under the auspices of the United States Atomic Energy Commission served as the basis for government regulations regarding the use of radioactive materials. The existence of these laws and well-regulated control measures has resulted in an excellent safety record for handling radioactive materials.

For this study, it was Battelle's responsibility to develop techniques for handling and installing the radioactive cylinder liner in the Fairbanks, Morse diesel test engine. A careful evaluation was made of all operations that would be involved. This evaluation was interpreted in terms of the radiation hazard presented by the radioactive liner. Handling and installation procedures were then considered for the purpose of developing procedures that would minimize the radiation hazard to all exposed persons.

Four months prior to the installation, a Battelle representative visited the Beloit Works of Fairbanks, Morse to observe all operations related to liner production, installation, and engine buildup. Observations were made of the time required to perform these operations.

After cylinder-liner irradiation it was possible to evaluate the radiation hazard that would exist during each operation. It was calculated that the total radiation dose received during pre-installation handling would range from 50 to 100 milliroentgens. It was estimated that an additional total exposure of about 1000 mr would be acquired during liner installation and engine buildup. That dose would be

Fig. 3 — Placement of capsule in reactor and drive mechanism for rotating specimen at 1 rpm.

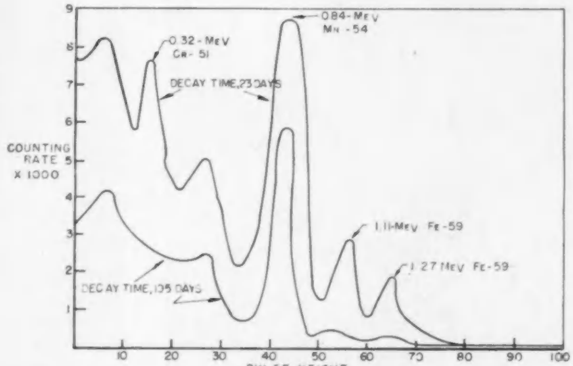


Fig. 4 — Spectrograph of radioisotopes produced in experimental cylinder liner.

Fig. 5 — Liner jacket installation.

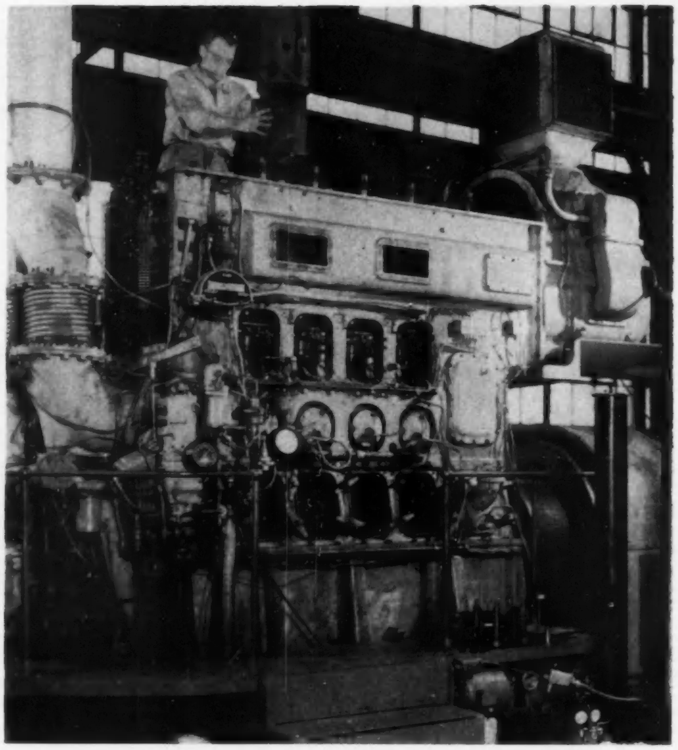


Fig. 6 — Three views showing various

Cylinder wear

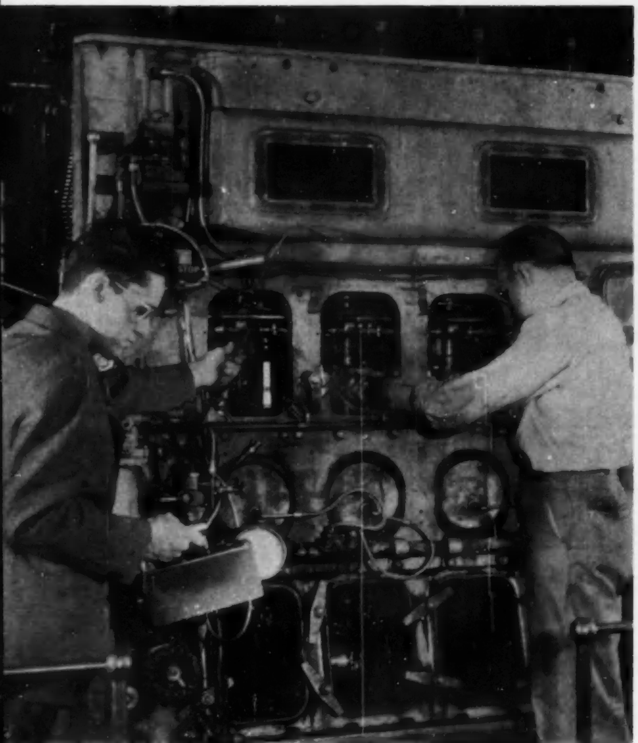
. . . continued

distributed among six to eight operators. It was apparent from these estimates that no single operator would receive the maximum permissible exposure of 300 mr per week if care were taken to rotate personnel for these operations. Because of the adeptness demonstrated by each operator for performing his individual task, the use of remote handling equipment was considered unnecessary. While remote handling would serve to decrease the radiation dosage rate, the resultant increase in time required for completing a remote-handling operation would result in an overall increase in cumulative dosage.

The specially crated lead-shielded liner was transported from Columbus, Ohio, to Beloit by truck. Operations involving jacketing, water testing, honing, and bore checking were all performed by production personnel at the normal production station used for each operation. Fig. 5 illustrates the liner jacket installation. During these operations the radiation hazard created in the area of the liner was evaluated with radiation survey meters. All personnel concerned with liner handling in any way were provided with radiation-sensitive film badges for recording cumulative dosage, and direct-reading pocket dosimeters. Accumulated radiation doses were determined intermittently from the dosimeters. All pre-installation handling operations were completed in 3 hr, and a maximum radiation dose of 80 mr was measured by the film badge for one operator. Other personnel received negligible dosages. Care was taken to insure the freedom of all areas and equipment from radioactive contamination.

Installation of the radioactive liner and engine buildup were completed in three 8-hr shifts. Two operators plus a supervisor were used for each shift. Film badges, dosimeters, and radiation-detection instruments were employed as safety measures. A Battelle representative was present at all times to supervise the handling of the radioactive liner and to make certain that radiation safety measures were being properly executed. Radiation doses measured with pocket dosimeters ranged from 35 to 80 mr. No one involved in engine buildup received more than the permissible dose. Fig. 6 illustrates the engine buildup.

After a normal buildup the engine and its immediate working area were evaluated as a radiation hazard. A suitable area was roped off about the engine at a sufficient distance to limit the radiation intensity beyond the designated zone to less than 2 mr per hr. Signs warning of the radiation hazard were posted to designate that zone. All personnel permitted inside the posted area were provided with either film badges or pocket dosimeters. A radiation intensity of 20 mr per hr was measured at the closest approach point of a man's torso to the installed liner, and an intensity of 60 mr per hr was measured at the closest approach point of a man's



stages of engine buildup.

hands to the installed liner. The maximum dosage received by an operator during all the operation of the engine was 60 mr per week.

Wear determination techniques

Radioassay techniques were developed to determine cylinder wear both qualitatively and quantitatively. These radioassay procedures were developed for analyzing wear products distributed in both the lubricating oil and exhaust gas stream. Throughout the experimental program lubricating oil and exhaust gas samples were simultaneously collected for analysis at 6–16-hr intervals.

The precision of the radioactive-tracer method was determined by comparing tracer-measured gross wear following each engine test with actual wear as determined from measurements using a bore-gage micrometer. This was determined by measuring four diameters of the cylinder at eight elevations before and after each test. These readings were averaged to determine the diametrical increase at each elevation and thereby the total volume of material.

Lubricating Oil Radioassay — Two methods were investigated for the radioassay of lubricating oil samples. The first method involved various techniques for removing and concentrating radioactive debris from lube oil samples. An advantage of this procedure was the inherently high efficiency of gamma-ray detectors for concentrated radioactive debris. Only limited success was achieved in developing a suitable technique for concentrating wear product debris because of an inability to perform uniform separation of a high fraction of the radioactive debris from lube oil samples.

The second, and selected, method was the direct analysis of untreated lube oil samples. Special counting techniques conducive to extreme instrument stability, and counting procedures resulting in a maximum statistical counting efficiency were employed for direct lube oil sample analysis. The analysis of liter-volume samples with an immersion scintillation crystal-type detector, coupled with a precision scalar were employed for lube oil analysis.

Exhaust Gas Radioassay — An exhaust gas sampler designed for the isokinetic sampling of 0.4% of the exhaust gas stream of the test engine was installed in the exhaust system (Fig. 7). Since the volume of exhaust filtered was small, the duration of operation of the system varied, depending on the actual debris carried by the exhaust gases. Debris collected on fiber glass filter mats was reduced chemically for assaying in the well counter. It should be pointed out that this chemical separation procedure was necessitated by the capacity of existing equipment. To handle the large number of samples expected during the utilization of this technique, a scintillation well counter was provided with a large dimension crystal to permit direct counting of the exhaust filter mats.

Radioassay Standards — Cylinder-liner metal filings radioactivated in both shielded and unshielded zones of the liner were processed for use as analytical standards. The properties of those standards were such that they would be subject to the same radioactive decay rates as was the cylinder-liner metal itself. These standards were radioassayed at periods corresponding to sample analysis, and used to compensate for the decay of the radioactive liner and for slight variations in instrument efficiency.

Data Processing — The actual wear could be calculated from the engine lube oil consumption rate and the assay information. These procedures were used in determining the data.

To Order Paper No. 126A . . .
. . . on which this article is based, turn to page 6.

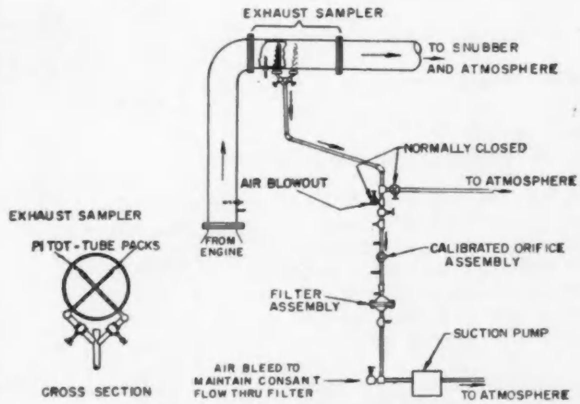


Fig. 7 — Exhaust gas sampling system.

CSDS Combines Aircraft Engine and Constant Speed

Low heat rejection unit provides electrical power during

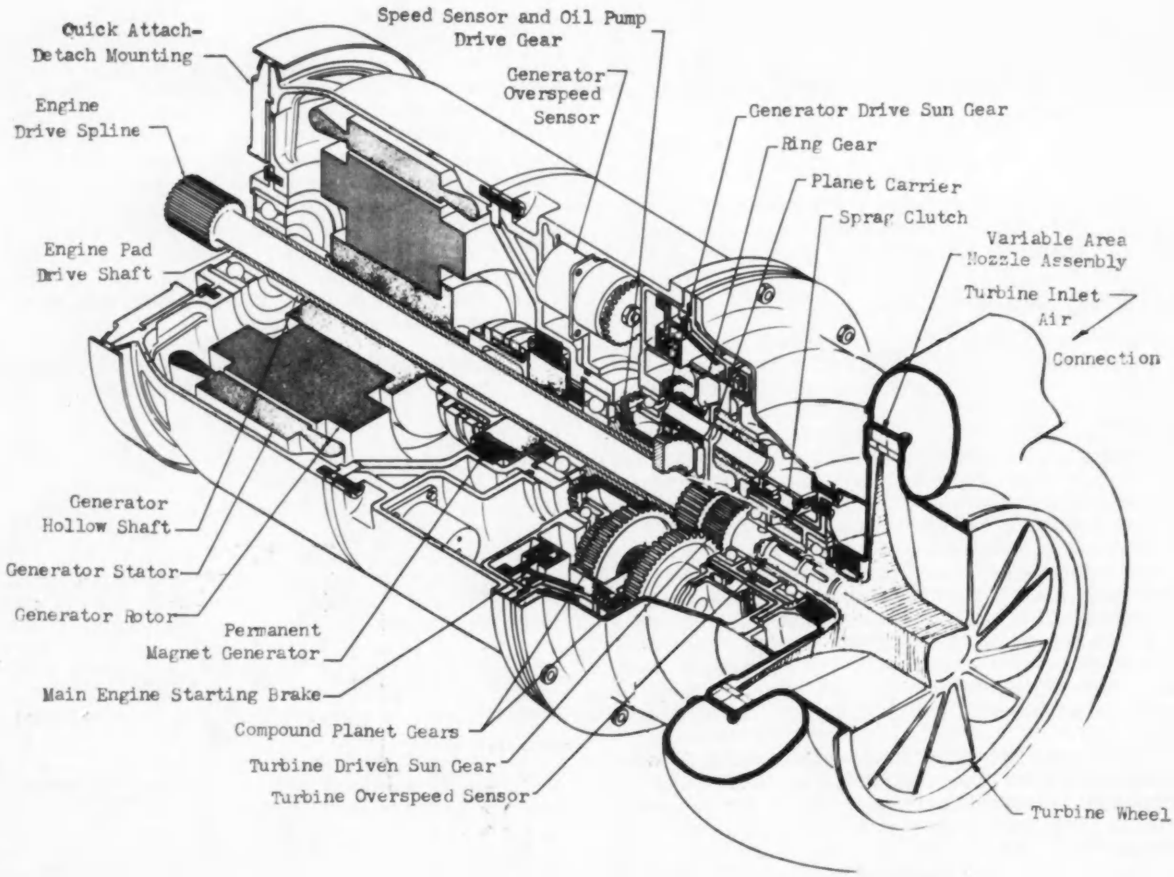
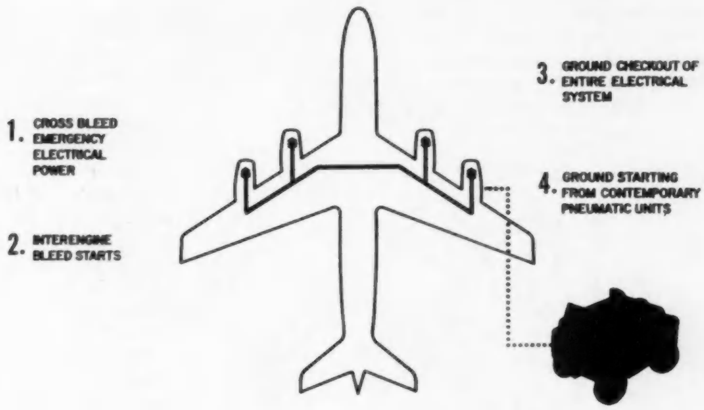


Fig. 1 — **Integral CSDS design.**

Starter Drive

engine operation, PLUS



Based on paper by

Palmer R. Wood

AiResearch Mfg. Co. of Arizona, Division of the Garrett Corp.

THE CONSTANT SPEED DRIVE STARTER (CSDS) combines an aircraft engine starter with a low heat rejection constant speed drive. It alleviates installation problems which arise from the use of constant frequency a-c power, and the weight, volume, and cooling problems due to increasing flight speeds.

This multipurpose unit provides in one machine the capability for:

- Main engine starting.
- Constant speed drive.
- Ground checkout of complete electrical system without operating main engine.
- Emergency electrical power from engine cross-bleed.
- Elimination of separate main engine starter and gear pad.
- Low heat rejection.

Configuration

During engine operation, the CSDS utilizes the conventional air turbine starter as a speed trim to compensate for variations in engine speed and thus provide a constant generator input speed. When the engine is not operating, this same air turbine can operate as an air turbine motor to provide the required generator power at constant input speed — when supplied with air from a gas turbine compressor or operating engine.

Main components are the generator, gear system (including starter brake), and starting turbine. Transmission system is composed of simple spur and bevel gear assemblies, so considerable design flexibility is possible to provide optimum combinations of gear ratios — depending upon engine speed ranges and aircraft requirements.

Integral Design — The hollowshaft generator design (Fig. 1) provides the minimum total volume for starter, drive and generator. Main power input during normal constant speed operation is from the main engine drive pad at the left. Speed control power is supplied by the starter turbine on the right, using compressor bleed or ram air. The differential gear train in the center connects to the output shaft which drives the generator.

The starting brake changes the gear ratio to provide the proper torque versus speed combination for engine starting. The sprag clutch prevents reverse rotation of the engine due to torque reaction during ground checkout operation.

Transmission gear system (Fig. 2) consists of two compound planetary reduction gear assemblies connected by means of a common ring gear assembly. Input shaft drives the planet carrier through the hollow generator shaft. Output sun gear on the generator shaft is driven by one planetary while the starter turbine shaft sun gear drives the other planetary.

Varying engine input speeds are compensated for by varying the turbine speeds to provide a constant

CSDS

. . . **continued**

output speed. With the planet carrier stationary (as during engine shutdown), input power from the starter turbine is supplied to the generator through the rotation of the ring gear assembly at a gear ratio suitable for constant speed operation. When the ring gear is stopped by the starter brake, the input power from the starter turbine is supplied to the main engine through the rotation of the planet carrier providing a gear ratio suitable for starting.

Capsule Design — Fig. 3 shows the capsule design, which has the advantages of less overhung moment and use of conventional generator. In this design, the turbine assembly and the transmission — as a package — are inserted into one side of the main engine accessory gear housing. Output end of the transmission (secured to the opposite wall of the accessory gear housing) is a standard AND pad on which a conventional non-hollowshaft generator may be mounted. Shaft power input to the transmission is through the bevel gear which is attached to the planet carrier in the transmission.

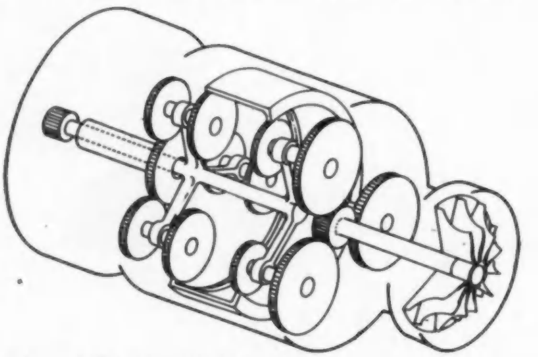


Fig. 2 — **CSDS transmission system.**

Sandwich CSDS — This design (Fig. 4) is used by most of the generator drive manufacturers. Transmission is mounted directly on the main engine pad, and the generator is mounted on the transmission. Input for the turbine assembly is through the bevel gears. This configuration has the advantages of fitting the existing aircraft installation and utilizing the generator already on the aircraft.

Control system

Speed control system (Fig. 5) is an isochronous system consisting of a pneumatic governor and servo providing position information to a hydraulic actuator. Hydraulic oil pressure is supplied to the actuator by the unit lubrication system to position the variable area nozzle of the turbine assembly. The pneumatic speed governor is a centrifugally actuated poppet valve, which senses generator speed and supplies a pneumatic signal to the servo. The servo, in turn, regulates the hydraulic actuation of the variable area nozzles, thereby controlling turbine speed to provide a constant speed input to the generator.

The basic speed control system will control generator frequency to within ± 1 per cent during steady-state operation over a wide range of operating conditions. This system can be augmented, if desired, by the addition to the servo of either a fine speed control or a load-sharing control, or both. The fine-speed control will control generator frequency to

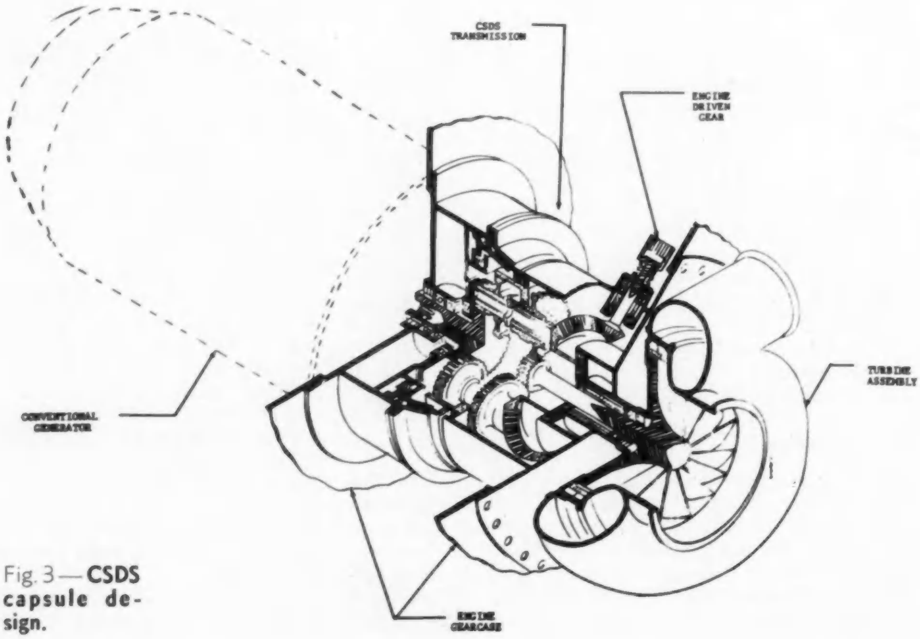


Fig. 3 — **CSDS capsule design.**

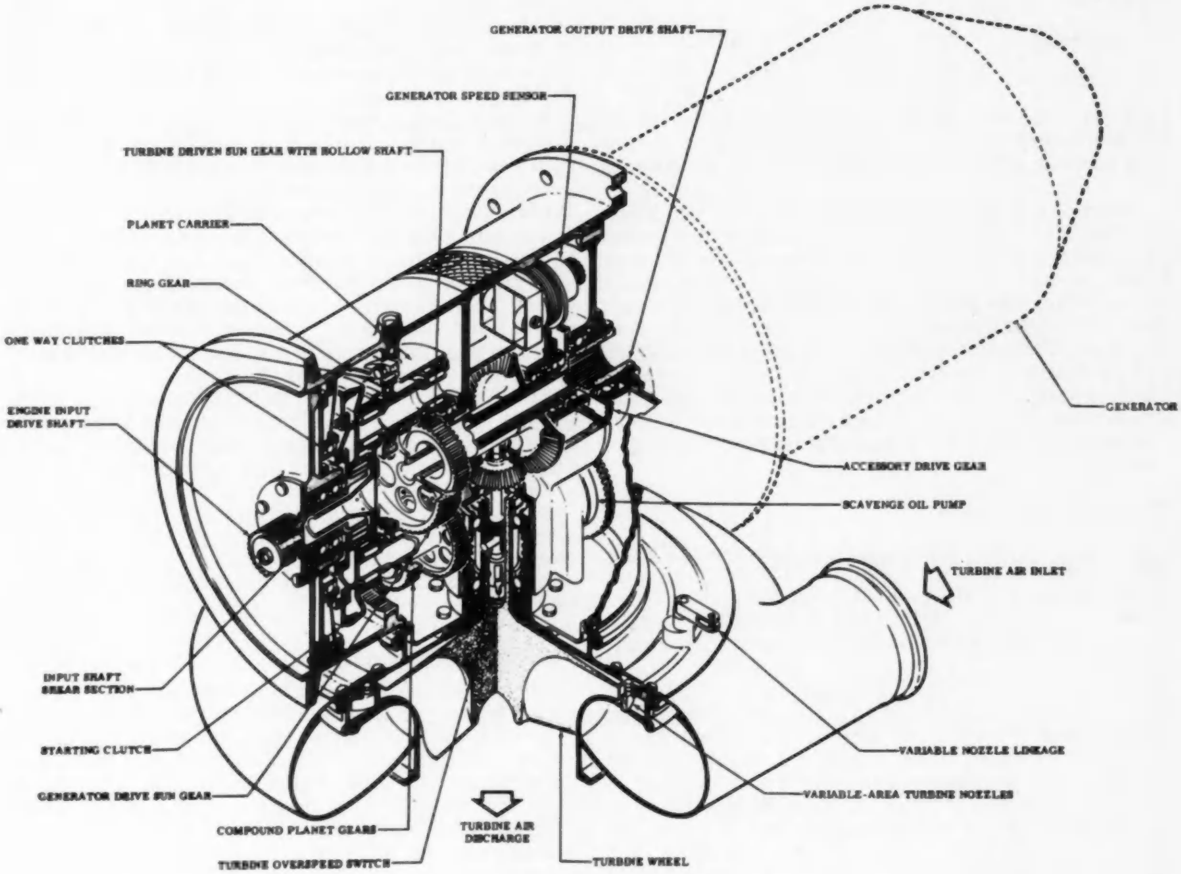


Fig. 4 — **Sandwich design.**

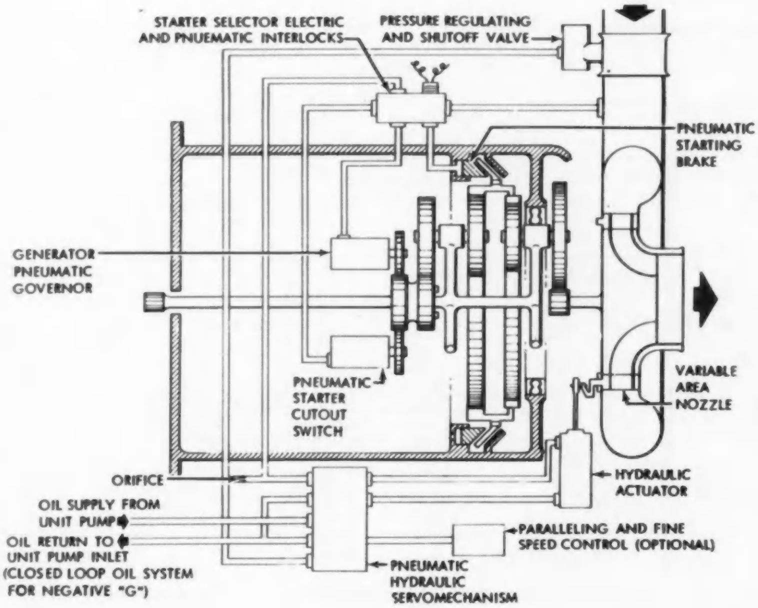


Fig. 5 — **CSDS control system.**

CSDS

. . . continued

±0.1 per cent during steady-state operation, while the load-sharing control permits parallel operation of a number of generators operating on a common bus.

When the selector switch is placed in the start position, the engine start switch may be actuated. This opens the inlet valve and actuates the starting brake, changing the unit to the starter gear ratio and bringing the centrifugally actuated starter cutout switch into the control circuit. At a preset cutout speed, the cutout switch actuates to switch back automatically to constant speed drive operation. Electric and pneumatic interlocks are provided in the starter selector to prevent selection of starter operation unless the inlet air valve is in the closed position.

Oil Heat Rejection

Average oil heat rejection of the Model CSDS200 (60 kw) machine is 3.4 hp or 135 Btu per min; and for the Model CSDS100 (20 kw) machine, it is 2.4 hp or 96 Btu per min. This is approximately one-fifth of the oil heat rejection for equivalent hydraulic drive units.

The CSDS has heat-sink potential. . . . For instance, a Mach 3 air vehicle, at an external static temperature of – 65 F, will have available ram air to the turbine at approximately 640 F. Power division between the main engine shaft input and turbine input could be such as to result in a turbine exhaust air temperature of approximately 200 F. This air could be used for accessory cooling, resulting in a self-cooled system using present state-of-the-art accessory and drive equipment. This could decrease the water needed for cooling purposes, as well as the size and weight of heat exchangers . . . and more fuel could be available for cooling the other aircraft accessory systems.

Performance and operation

Fig. 6 shows turbine speed as a function of engine input shaft speed for a typical CSDS unit. In the ground-check or cross-bleed mode of operation where engine input shaft speed is zero, the turbine runs at a constant speed of 70,783 rpm. The transmission serves as a reduction gear system with an output of 8000 rpm.

During main engine starting operation, there is a 14.44 gear ratio between the turbine and the engine drive shaft. Turbine speed reaches approximately 46,000 rpm at nominal starter cutout.

When this unit uses engine input shaft power, operation is from minimum engine idle speed (4000 rpm) to maximum engine speed (7900 rpm) with corresponding turbine speeds of 41,000 to 8200 rpm. When compared to a wheel failure speed of 140,000 rpm, the CSDS unit permits an exceptional safety margin in turbine wheel design for the speed required by all of the different modes of operation.

Fig. 7 shows calculated performance at 35,000-ft cruise condition for a typical commercial transport. At generator output of 30 kw, the CSDS requires 11 lb per min of bleed air and 42.5 shp.

Electrical output of the Model CSDS200 as a function of inlet air flow for ground checkout operation is shown in Fig. 8. On a standard NACA Sea Level Day, a 94-lb-per-min air flow will produce 60-kw generator output.

Main engine starting is shown in Fig. 9 — output torque and torque required by the J-57 engine are shown. Under these conditions, the calculated starting time to starter cutout is 12 sec and to engine idle is 17 sec.

Future applications

The CSDS unit has potential capability for a self-cooled system in high-speed aircraft by use of ram-air energy for the speed control turbine. Since this reduces exhaust air temperature to a level which can be used as a heat sink, it enables the use of currently available equipment. Since it can operate from either engine shaft plus bleed or ram air, or from bleed or ram air alone, this makes an ideal arrangement for a combination turbojet-ramjet driven air vehicle. It is ideal for nuclear powerplants, as it can be used for prolonged engine motoring operations by utilizing bleed-air energy. Finally, it has potential growth capabilities for use on engines in aircraft where large electrical loads are required which, under certain engine speeds, exceed the load limitation of the engine pad. Here, the power division capability between engine shaft input and turbine input can be utilized to permit the use of much larger alternators and accessories.

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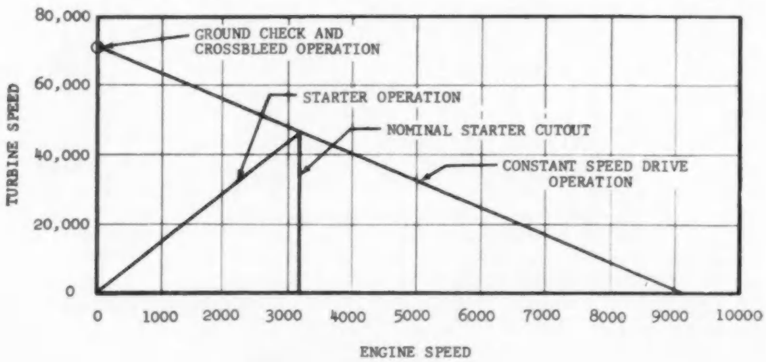


Fig. 6 — **Turbine speed** as function of engine input shaft speed for typical unit.

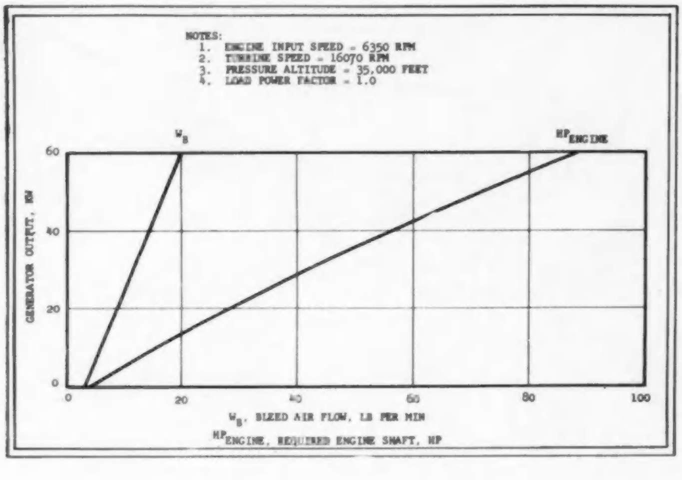
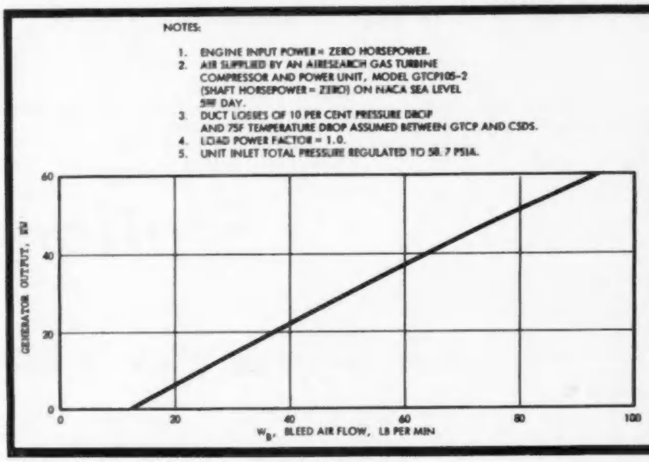


Fig. 7 — **Calculated performance** at typical engine cruise condition.

Fig. 8 — **Electrical output** of CSDS 200 as function of inlet air flow for ground checkout operation.



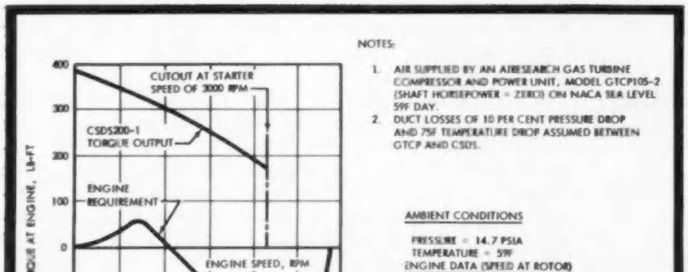


Fig. 9 — **Main engine starting operation,** showing output torque and J-57 torque requirement.

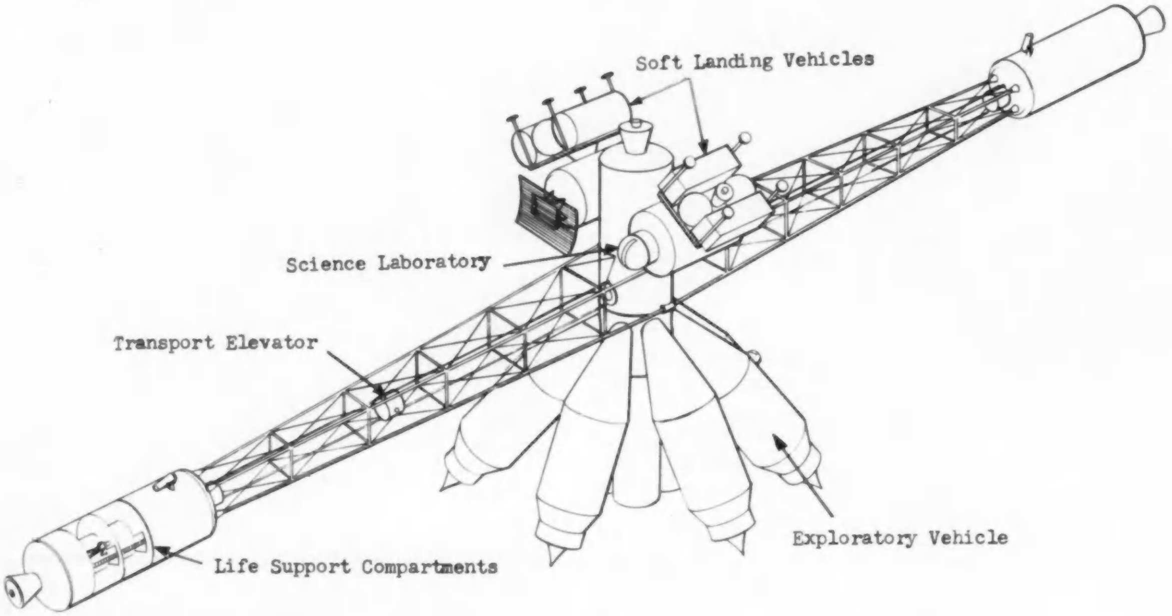


Fig. 1 — 500,000-lb space station complete with life support compartm:nts, communications equipment, interplanetary vehicle docks, refueling tanks, and scientific laboratory, in orbit 500 miles above the earth.

Stations in Space . . .

. . . how to get up there to build them and get back again — with nuclear rockets.

Based on paper by

Holmes F. Crouch

Norair Division, Northrop Corp.

NUCLEAR rockets afford one means for establishing advance stations for interplanetary frontier exploration. They have great possibilities, also some limitations.

A typical manned space station is shown in Fig. 1. It would be located in excess of 500 miles altitude from the earth and weigh on the order of 500,000 lb, necessitating construction from prefabricated plug-in or snap-on parts, raised one or two at a time, and assembled in orbit.

The powerplant of the rocket is shown in Fig. 2. The rocket reactor heats the hydrogen propellant. This propellant heater consists of a multitude of nuclear fuel elements, each composed of graphite, fissionable fuel, and the structure for holding it in place. For sufficient quantities of propellant to pass along these fuel elements, an amount of nuclear void space is required — on the order of 30%. The propellant would reach the nozzle at about 3500 F, or appreciably less than the 5000–6000 F range of chemical rockets.

The nuclear void space, high reactor temperature, and necessity for keeping reactor weight down are responsible for the nuclear fissions occurring at relatively high neutron energies. Thus, we have a fast fission reactor instead of the thermal fission reactors found commonly in nuclear plants. The consequences of the fast reactor which must be accepted are:

- Greater amount of nuclear fuel required.
- Greater neutron leakage.
- More difficult reactor control.

Nuclear reactor power

In all probability, the reactor power would range in the 5000 megawatt size, approximately the thrust

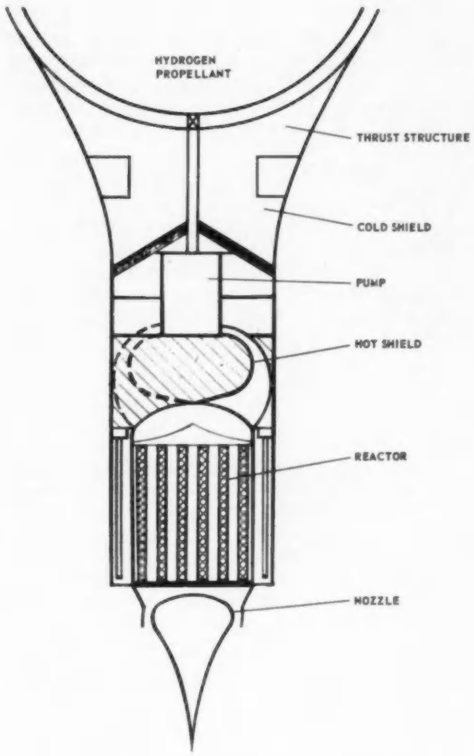
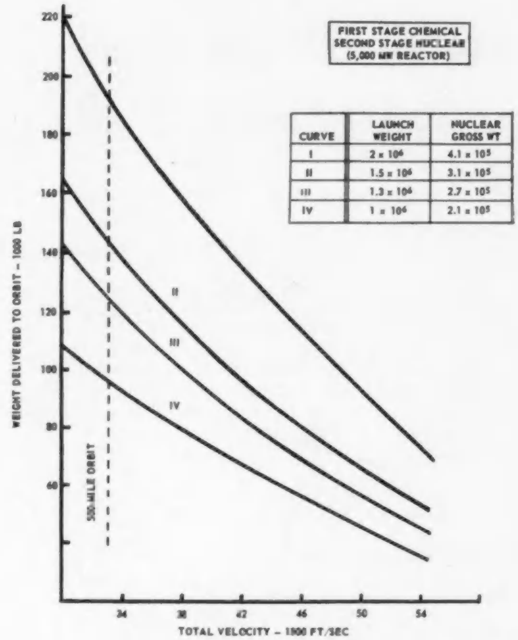


Fig. 2 — Nuclear rocket powerplant with its five components, to be used for lifting parts for assembly into a space station.



CURVE	LAUNCH WEIGHT	NUCLEAR GROSS WT
I	2×10^6	4.1×10^5
II	1.5×10^6	3.1×10^5
III	1.3×10^6	2.7×10^5
IV	1×10^6	2.1×10^5

Fig. 3 — Payload-to-orbit capability obtained by marrying a multimillion-pound thrust, first-stage chemical engine to a 5000-megawatt nuclear second stage.

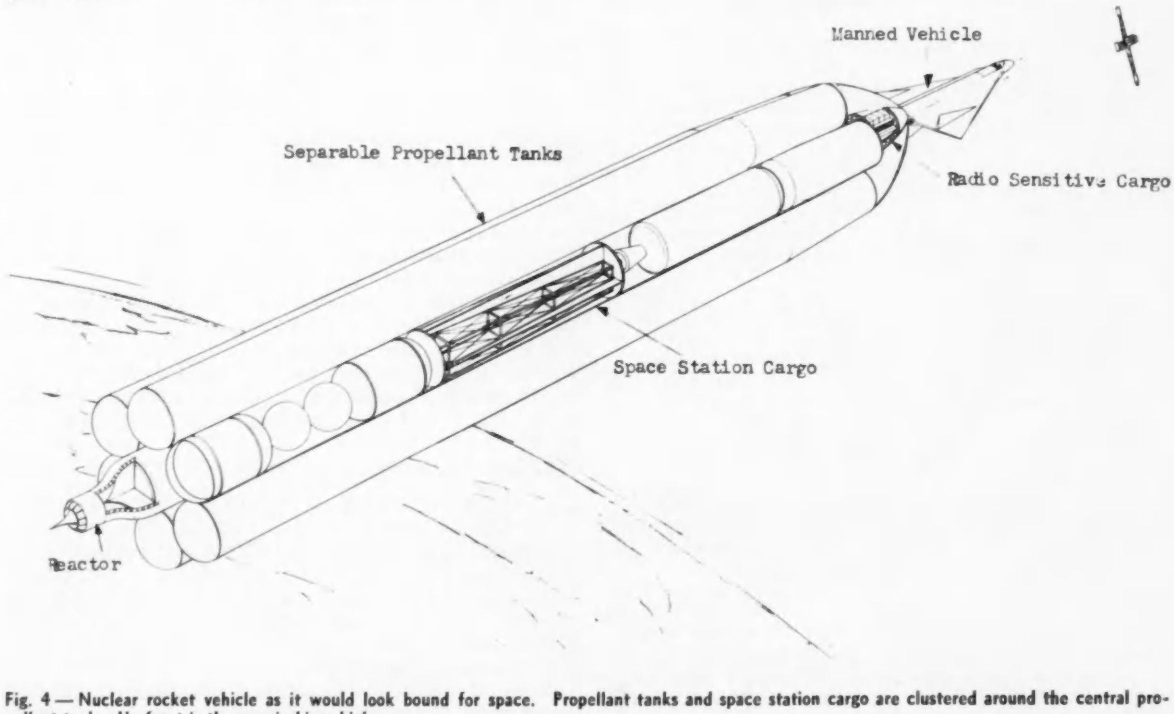


Fig. 4 — Nuclear rocket vehicle as it would look bound for space. Propellant tanks and space station cargo are clustered around the central propellant tank. Up front is the man in his vehicle.

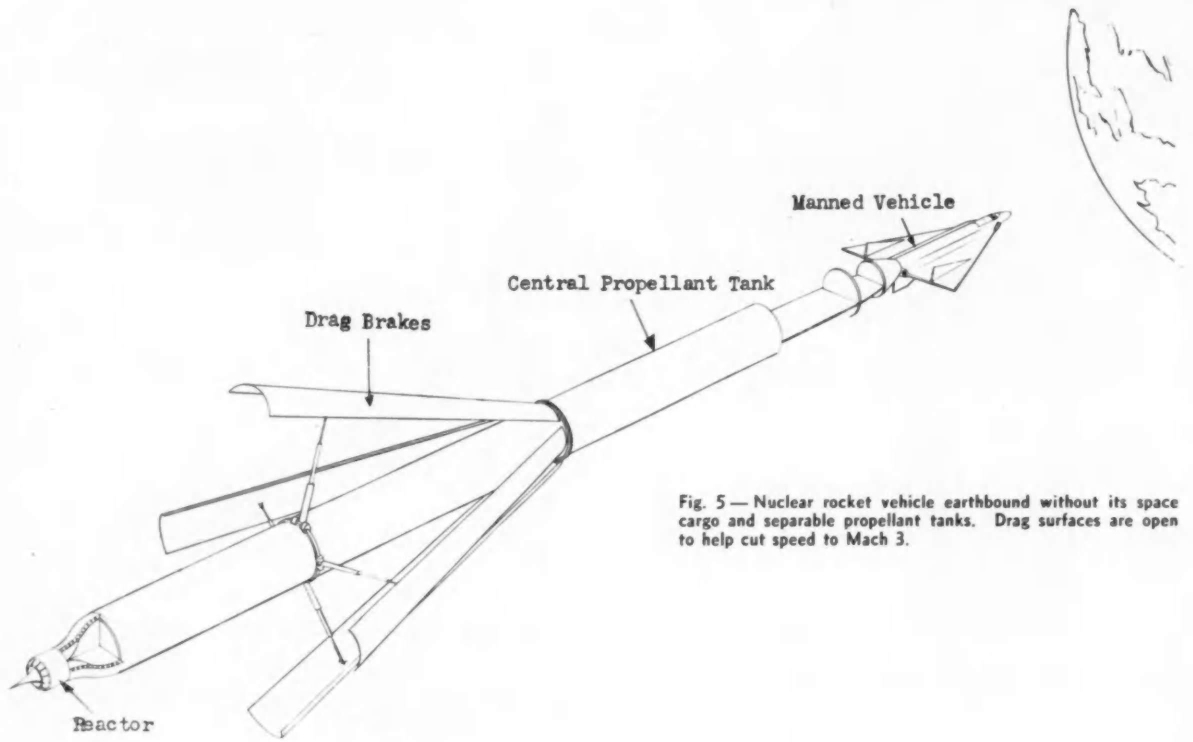


Fig. 5 — Nuclear rocket vehicle earthbound without its space cargo and separable propellant tanks. Drag surfaces are open to help cut speed to Mach 3.

Stations in Space

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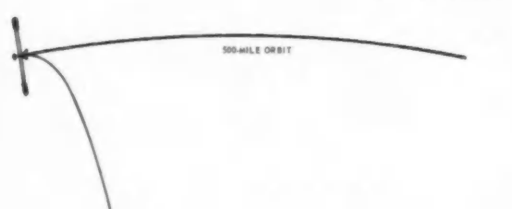


Fig. 6 — Re-entry trajectory of a nuclear rocket vehicle as it "steps" down from a space station. At 20 miles above the earth the pilot jettisons reactor and propellant tank and returns to base in his turbojet-powered flying machine.

equivalent of the Atlas or Titan first stage. The maximum, single-engine thrust capability, regardless of rocket type, might be 1.5×10^6-lb thrust, equivalent to one NOVA engine. Nuclearly, this thrust is equivalent to a 30,000-megawatt reactor, which is not apt to be built in the near future. Therefore, we'd accept a 5000-megawatt reactor and marry it to one of the chemical rocket systems. This would improve payload and provide controlled re-entry capability.

Fig. 3 presents four curves representing multi-million-pound thrust, first-stage chemical engines married to a 5000-megawatt nuclear second stage. Curve III shows we would arrive at a 500-mile orbit (33,000 fps velocity requirement) with about 125,000 lb, including the reactor deadweight. To return 20,000 lb to earth and use the reactor for re-entry deceleration, it would be necessary to leave the orbit with about 100,000 lb, leaving 25,000 lb behind.

Nuclear ferry vehicles

A nuclear rocket ferry vehicle might consist of a 20×150-ft central propellant tank with a special cargo space and manned vehicle for orbit at one end of the tank (Fig. 4). Propellant tanks would be clustered toward the powerplant end around the central tank, to be separated when the propellant is consumed. Space station parts would also be clustered around the central tank. Fig. 5 shows the vehicle shorn of its space station parts ready for homeward flight.

Launching the space vehicle

Due to the dangers of contamination, nuclear power would not be used for launching. Chemical boosters, probably using solid fuels, would get the reactor into the upper regions of the atmosphere and at about 20 miles altitude the reactor could take over. Meanwhile the reactor would be started up but idling.

With nuclear rockets the rendezvous problem need not be a major concern. The reactor nozzle would have variable-flow and retrothrust capability to permit the necessary orbit verniering to get the space station parts together. The rockets need never be shut down. They can be left simmering, ready to go at all times, and this imparts a high degree of maneuverability.

Advantages for re-entry

Much effort and a considerable amount of nuclear fuel would be needed to get the reactor into space, but once there it could be used for purposes inconceivable with chemical rockets. Re-entry is a prime example. Power is required for decelerating into the atmosphere just as power is required to accelerate out of it. Once the reactor is aboard, the additional fuel for deceleration is negligible; the additional propellant needed is not prohibitive.

"Criticality fuel," the amount required to maintain self-sustaining nuclear fission at operating temperature, always remains in the reactor; it is never consumed. It is the power fuel that is consumed and this is a negligible per cent (order of 0.05%) of the criticality fuel. Expressing criticality fuel in dollars at $15 per gram, there remains in the reactor close to $4,000,000 worth of unused fuel. The reactor must be brought back to earth to salvage the unused nuclear fuel; the reactor itself is relatively unimportant.

How to get back home

A typical re-entry trajectory is shown in Fig. 6. The rocket vehicle — reactor, propellant tank, and manned vehicle — would return from orbit in stepwise fashion. The vehicle components of the steps represent pulses of high deceleration (order of 10*g* for 5 sec); the horizontal components represent letup glides at constant deceleration tolerable for the pilot (order of 2*g* for 30 sec). The object of these steps is to slow down from hypersonic speeds to a flight speed of, hopefully, Mach 3. Here, drag surfaces are useful. Mach 3 could be attained sometime prior to a 20-mile altitude, at the time of booster separation.

The pilot would then release the reactor, an instant later let the propellant tank go, and then be on his own in a turbojet vehicle to return to his airfield. The trip? About 5 hr, of which 4 hr would be in orbit — a rigorous day's work.

Because the nuclear reactor could not be re-used, a fleet of nuclear rockets would have to be readied to assemble a manned space station. Probably this won't happen much before 1970, though it need not be as late as 1975.

To Order Paper No. 167A . . .
. . . on which this article is based, turn to page 6.

Purchasing Has Its Say On Engineering Actions

Based on report by panel secretary
D. R. HANNUM
Chrysler Corp.

WHAT ENGINEERING'S RESPONSIBILITIES are to purchasing is pretty well agreed by purchasing executives of major automotive vehicle and parts plants. Purchasing men from Ford, Cadillac, Chrysler, and Eaton recently concurred in a good many opinions about engineering's proper responsibilities to purchasing.

For example:

1. Purchasing wants complete prints and specifications as long in advance of production dates as possible.
2. There should be no source restrictions on any items.
3. Items should be engineered so that they can be produced easily.
4. *No* engineering changes should be made after prints have been released.
5. Engineers should discuss forward programs and designs with purchasing much earlier than they usually do.
6. Engineers, who never reach the ultimate in a design should cut loose their releases at a time that is mutually agreed (with purchasing) to be realistic.
7. Final and complete releases are needed on dates which *by experience* have proved to contain no "pad."
8. Selection of sources for engineering prototypes should be selected jointly.
9. Tip-offs from engineers to purchasing on pending engineering changes help. It gives purchasing a chance to hold the supply of old parts to a minimum.
10. Many areas of responsibility are common—between engineering and purchasing . . . so cooperative action plays a major part in supplying quality products on a timely basis.
11. Adequate procurement lead time is essential.

The major purchasing problem can be expressed as "obtaining purchases at the lowest economical cost in keeping with applicable specifications." So when the specifications call for gold and champagne, this lowest economical cost turns out to be a very "high" low.

To meet such situations, some purchasing departments have formed what they call "value analyses" groups. These groups analyze parts and assemblies to determine if the required functions can be accomplished less expensively in some other manner. . . . But such analyses, it would seem, are properly the responsiblity of the engineering rather than the purchasing department.

(The material in this article is drawn from a report of a panel on "Engineering's Responsibility to Purchasing.")

Low Voltage Ignition Will Start Cold Diesels

Based on paper by

L. P. ATWELL, W. P. BRUMBACK, and W. R. MANTHEY

Electric Autolite Co.

(Presented before SAE Central Illinois Section)

COLD starting of diesel engines is feasible with low voltage ignition and it is quite possible that a single standard power supply will suffice for all diesel appplications.

Tests have been conducted with a 1-cyl, 4-stroke, aircooled, Onan diesel of precombustion-chamber design and a 3-cyl, 2-stroke, liquid-cooled, Model 371 GMC diesel of open-chamber design. Both engines were started consistently in 8–10 sec at – 25 F, using JP4 fuel, and the minimum energy required for a successful start was about the same for both engines. In both cases it was necessary to operate the engine for about 1 min as a spark-ignition engine to develop sufficient combustion-chamber temperature to permit normal operation.

Spark-plug location in the precombustion-chamber engine was very critical. Starts could be made only with the spark plug located in the precombustion chamber. With the GMC engine, satisfactory starts were made with the plug in the side of the combustion chamber as well as in one of the valve locations. However, since no start could be made with the GMC engine with low voltage plugs in two of the three cylinders, the need to have one plug in each cylinder of a multicylinder diesel is indicated.

Ignition timing appears to be critical for a timed spark discharge in a precombustion-chamber engine, and it is conceivable that continuous ignition without a distributor will be satisfactory. This possibility is now under investigation.

To Order Paper No. S241 . . .
on which this article is based, see p. 6.

Mileage Cuts Wear Protection of MS Oils

Based on paper by

D. W. GOW

Gulf Research & Development Corp.

(Presented at SAE Southern California Section)

THE ABILITY of MS oils to combat low-temperature, corrosive wear is significantly reduced when the oils are used for extended mileage. This is the finding of radioactive, low-temperature tests to evaluate oils taken from engines operated under controlled service conditions.

While most of the MS oils tested gave similar protection when new, some lost their effectiveness much more rapidly than others as mileage was accumulated. This demonstrates the fallacy of appraising quality of new oils on short-duration tests alone. When used for extended periods, MS oils lost much of their capacity to give protection against the formation of low-temperature engine deposits.

Method of Testing

Tests were conducted with a single-cylinder, CLR oil test engine equipped with a radioactive, cast-iron, top compression ring. A cast-iron ring was used in preference to a chrome-plated one because it is in more common use, is more subject to corrosion, and because cylinder walls and other rings are still being made of cast-iron and subject to similar corrosive wear.

As ring wear occurs, the small radioactive wear particles are picked up by the lubricating oil that is continuously passing through a glass sensing wall and returning to the oil sump. A scintillation counter is mounted in the sensing well and detects the gamma rays that are emitted from the radioactive iron particles. Electrical pulses from the counter are counted and recorded by a count rate meter and Esterline Angus recorder. To convert counts per minute to milligrams of ring wear, a known amount of an irradiated ring sample is dissolved in acid and the solution used as a calibration sample.

When the data for all oils under uncontrolled field service were combined and compared with new oils it showed the average wear rate increasing 25% after 500 miles of use, slightly more than twice as great after 1000 miles, and five times as great after 2500 miles.

To Order Paper No. S233 . . .
on which this article is based, see p. 6.

Diesels Gaining: Some Problems Still Ahead

Based on paper by

E. R. KLINGE

Ford Motor Co.

IN THE FUTURE, as in the past, diesels will have to earn back — through fuel economy, lower maintenance cost, and greater vehicle availability to meet operator schedules — a 25–50% weight penalty and a 50% higher price tag. These relationships are likely to continue, even though smaller, lighter, and less expensive diesels are on their way, and gasoline and diesel engine sizes have to come very close together for a given horsepower. Particularly is this true for heavy-duty service where the rating on both engines is limited by durability requirements and fuel economy . . . and not by maximum potential hot rod output.

Higher diesel speeds are becoming practical through combustion research and the gradual use of shorter-stroke engines. The turbocharger art has advanced remarkably in the past five years and usage will spread. Output increases of 20–25% by this means can readily be withstood by most engines without significant loss in durability.

Actually, output increases of 50–100% can be achieved. But very careful evaluation must be carried out on total powerplant characteristics and durability to assure success. Special engine designs may also be necessary for these extreme outputs. Fuel injection equipment is subjected to continuous review — and its costs are gradually dropping as newer designs appear, and as greater diesel acceptance permits higher volume tooling to be financed.

Diesel-engine tooling is also improving, as diesel acceptance grows and permits more extensive tooling to be financed. Efforts are continuously being made to reduce tooling costs by conversion to diesel production of equipment already tooled for gasoline engines. . . . These efforts meet with varying success, depending on the design of the original gasoline engine. (Editor's note: The January 1960 SAE Journal carried an article (p. 42) detailing how International Harvester Co. designed a new family of diesels to make maximum use of existing gasoline-engine tooling)

Diesel Problem Areas

Problem areas through which the diesel still must make progress — as defined in terms of potential application — are:

Heavy Highway Tractor (200–350 hp)
- Reduced weight
- Reduced size
- No sacrifice in maximum fuel economy or maximum durability
- Cost can yield slightly to obtain values above

Medium Highway Tractor (125–175 hp)
- Lower cost
- Greater durability

Medium City Delivery (100–125 hp)
- Lower cost
- Reduced size
- Less smoke
- Less odor
- Easier cold starting

Light City Delivery (75–100 hp)
- Lower cost
- Wider speed range and flexibility
- Reduced size
- Reduced weight
- Less smoke
- Less odor

Easier cold starting
Less vibration and noise

Lower cost appears rather regularly as a problem. The reason for this emphasis is borne out by an examination of a typical diesel-engine operating cost summary. It might show that 50% of the cost was depreciation, 30% fuel, and 20% maintenance (whereas a gasoline engine might be 50% fuel, 25% depreciation, and 25% maintenance). Since the depreciation (or engine and installation cost) is the dominant item in the story, some crystal ball gazing may be in order concerning it.

Diesel-engine costs per horsepower are about two and a half times that of gasoline engines designed for heavy-duty service and when similarly tooled. When compared to the expensively tooled automotive gasoline engines, diesels may cost three to five times as much. Also, added cost may be incurred in the vehicle installation due to higher driveline torque requirements. These high diesel-engine costs are primarily due to:

- A heavier engine to withstand higher gas and shock loads in the cylinders.
- Lower engine rated speed and bmep resulting in lower output per lb of engine and a heavier engine per horsepower.
- Conservative heavy-duty design generally aimed at longer life than the competitive gasoline engine.
- High cost fuel metering system.
- Low volume tooling (in most instances).

To Order Paper No. S237 . . .
on which this article is based, see p. 6.

Collision Studies Reveal Gruesome Facts

Based on paper by

D. M. SEVERY, J. H. MATHEWSON and A. W. SIEGEL
Institute of Transportation & Traffic Engineering, University of California

WHAT happens to cars and occupants when two cars, traveling at 30 mph, collide at an intersection? Three fully instrumented studies were conducted with anthropometric dummies to find the answers.

When the struck car was hit just forward of the driver, it rolled over. When the impact was at the center of the side, both cars rolled over. Neither car rolled over when the impact was from the rear side, but the driver of the struck car was ejected. In each case the angle of collision was 30 deg.

These studies demonstrated the value of restraining belts in a dramatic fashion. In reporting the injuries sustained by the occupants, the inferred diagnosis for the unbelted dummy is most often fatal, probable fatility, or probable survivor, whereas with the belted dummy the diagnosis is survivor, probable survivor, or possible survivor.

The paper presents a detailed description of the photographic, electronic mechanical, and physiological instrumentation used, describes and illustrates each of the tests, and summaries the results to cars and occupants.

To Order SP-174 . . .
on which this article is based, see p. 6.

Bearing Performance In Oronite 8200 Fluid

Based on paper by

JOHN H. JOHNSON
Marlin-Rockwell Corp.

TESTS of bearings submerged in Oronite 8200 hydraulic fluid at 450 F showed little deterioration of the fluid and provided no evidence warranting the derating of roller bearings from AFBMA predicted lives under conditions of the test.

All test work was conducted on an MRC 5-spindle, special lubricant, test rig, at speeds of 6000 rpm with a radial load of 1625 lb per bearing, and with the hydraulic fluid flowing through the system at a rate of 0.8 gpm per spindle.

Bearing failures did take place during one phase of the test and these are attributed in the main to misalignment resulting from warping of the test housing covers. Investigation is being undertaken to see if the fluid played a part in the deformation. The fact that bearings containing used parts, and known to have been subjected to high stress concentrations, showed superior performance is attributed to differences in roll material.

The tests indicate that the system designer should not compromise his design from the standpoint of bearing operation in this fluid. Furthermore, care should be taken in drawing conclusions for other loads, speeds, or temperatures, and results should not be extrapolated to ball bearing operation.

To Order Paper No. 176A . . .
on which this article is based, see p. 6.

Flame Radiation Studied In Gas Turbine Combustors

Based on paper by

R. M. Schirmer, L. A. McReynolds
Phillips Petroleum Co.,

and J. A. Daley
Aeronautical Engine Laboratory, Naval Air Material Center

THE need to improve aircraft gas turbine engine reliability and performance dictates that the barrier of high intensity flame radiation be moved back; either by more critical specification of fuel hydrocarbon type or by advancements in control over the physical and chemical processes involved in high pressure pyrolysis of hydrocarbon-air mixtures.

The effect of monocyclic versus polycyclic aromatic components (in JP-5 fuels having the same ASTM Smoke Points) on total flame radiant energy was investigated. The performance of research combustors and a J79 aircraft gas turbine engine single combustor operated at low (atmospheric) pressure showed variations in aromatic type or content with the present JP-5 specification to have no significant effect on flame radiation.

The performance of research combustors and a J57 aircraft gas turbine engine single combustor operated at high (5 to 15 atmospheres) pressure showed that polycyclic aromatic fuel blends burn with higher flame emissivities than monocyclic aromatic fuel blends of comparable ASTM Smoke Point.

Radiant heating of metal parts was shown to be a function of their location in the combustor because quenched combustion products can effectively absorb, or "screen-out" flame radiation.

A characteristic relationship between total flame radiant energy from a J57 combustor and CRC Luminometer Number was obtained with 12 test fuels covering a broad range in burning characteristics. Because of the excellent correlation between fuel ratings obtained with the ASTM Smoke Lamp and the CRC Luminometer, it seems desirable to consider the latter as an alternate for characterizing fuels beyond the limit of the present test method.

Use of low luminosity fuels gave major reductions in liner temperatures in the J-57 combustor; however, such fuels do not insure large reductions in heat transfer to metal parts. This is shown by a reduction of only 40 F in the afterburner liner temperature of a J-75 aircraft gas turbine engine obtained with JP-150.

To Order Paper No. 114B . . .
on which this article is based, see p. 6.

4 Research Areas Needed for "Direct Conversion" Space Ships

Excerpts from paper by

T. F. NAGEY and
R. E. HENDERSON
Allison Division, GMC

THE following four research areas are of importance for development of large direct-conversion electrical powerplants for space missions.

Energy Source — It is likely that large solar convertor systems can be developed by 1975, so that a clean system may be employed. Of particular interest here is the development of a dependable orientation system and a high efficiency solar collector system.

For instance a solar collector with a photon to photon conversion efficiency of 50% and a specific weight of 0.2 psf, which is close to reality today, would supply the heat energy to the fuel cell system with a weight of 25,000 lb in the vicinity of the earth. Further, this type of collector would be capable of providing temperatures of 1500 K to the thermionic convertor. If a concentrated research program were started today, solar collectors would be available by the time this requirement were realized that would be considerably lighter than the above specifications.

Converters — The fuel cell system has a high inherent efficiency. However its high weight detracts from its usefulness for this application. This is a problem of fuel cell kinetics or the acquiring of higher reaction rates in fuel cells. Regenerative fuel cells with high current densities require research.

A combination thermionic-thermoelectric system should be developed. This system could operate with each unit converting heat energy in the regime where it is most efficient. Efficiencies of 20% appear to be possible for this kind of unit in the near future.

Pumps — Higher efficiency lower weight d-c electromagnetic pumps are sorely needed for applications of this type. With a good research program, field fringing, one of the main causes for the inefficiency of electromagnetic pumps, could be cut so that pumps with an efficiency of 50% could be realized.

Radiator — Continued development of radiators of the type indicated in Fig. 1 is required to insure minimum radiator weight.

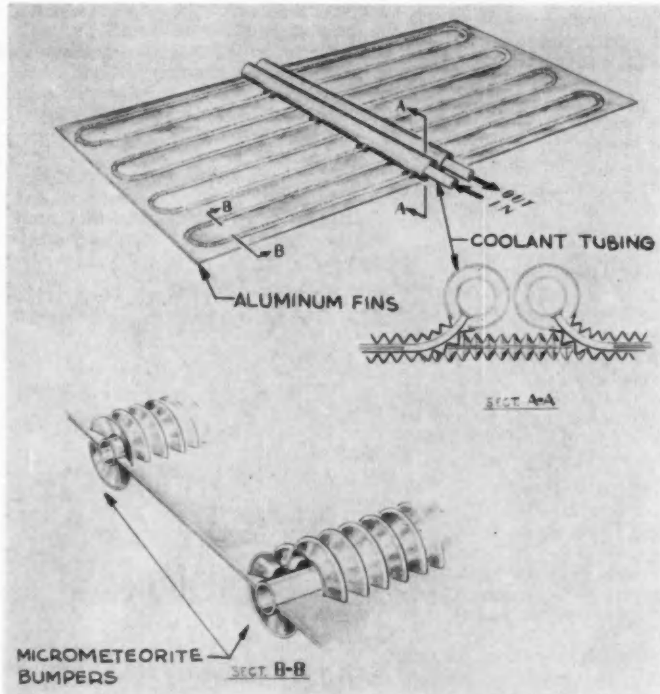


Fig. 1 — Typical radiator design — to ensure minimum radiator weight.

Future Systems

Since reactor weight is not highly sensitive to power in this regime, increases in convertor efficiency will not cause a lowering of reactor weight as they will to a solar reflector. Thus it appears that, by doubling convertor efficiency and halving solar reflector specific weight, one megawatt solar space powerplants will not be appreciably different in weight from a reactor powerplant.

Table 1 compares the approximate weights for a solar and nuclear thermionic-thermoelectric one megawatt system possible in 10 years if the research areas mentioned are pursued vigorously. A convertor efficiency of 25% is assumed and working temperatures would be 1500 K to 500 K.

The weights in Fig. 2 assume significant reactor development toward higher temperature operation. Electromagnetic pumps with 50% efficiency are employed.

Fuel cell system comparisons will be the same between nuclear and solar. Their competitive position depends upon the success of specific weight reduction achievable.

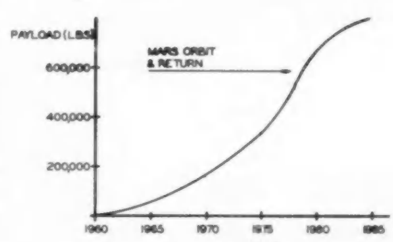


Fig. 2 — Estimated U. S. payload capability for 150-day Mars trip and return (manned), if significant reactor development toward higher temperature operation is assumed.

To Order Paper No. 120B . . . on which this article is based, see p. 6.

Table 1 — Future Thermoelectric-Thermionic Convertor Systems
(All values in pounds)

Solar		Reactor	
Reflector Weight	6,000	Reactor Weight	7,000
Radiator Weight	27,000	Reactor Weight	27,000
Pump to Radiator & Coolant	3,000	Pumps and Coolant	6,000
Convertor Weight	80,000	Convertor Weight	80,000
Total	116,000	Total	120,000

SAE NEWS

Charter to Manhattan College Makes It SAE's 57th Student Branch

AN SAE STUDENT BRANCH AT MANHATTAN COLLEGE was launched last month when the SAE's Board of Directors approved the Sections Board's recommendation that a charter be granted to the former Club. Manhattan becomes the fifth SAE Student Branch in the Metropolitan Section area. The others are: New York University, chartered 1929; College of the City of New York, 1942; Academy of Aeronautics, 1950; Stevens Institute of Technology, 1951.

William A. Bautz is chairman of the new Student Branch; Paul Vermaelan, vice-chairman; Joseph Corcoran, treasurer; John A. Gardiner, corresponding secretary; John O'Brien, recording secretary; Brian O'Hare, historian. Prof. Alfred Del Vecchio, Manhattan College's director of mechanical engineering, is faculty advisor.

The spring of 1960 marks the 107th anniversary of the founding of Manhattan College. First, St. Vincent's Academy was organized on Canal Street — and four years later it was moved to Manhattanville (a tract of land east of Broadway and north of 131st Street.) Here, in May 1853, the foundation of the College was laid. One year later, the institution was incorporated and chartered to confer academic degrees by the University of the State of New York.

In 1921, construction of buildings on the present site in Riverdale-on-the-Hudson was begun and complete transfer to the new campus was effected in 1923.

The engineering curricula are accredited by the Engineers Council for Professional Development. A recently completed Engineering Building houses the School of Engineering, which has as objective "to train the whole man and to provide an enduring foundation for professional life by blending a humanistic basis for scientific technology advance with sound training for professional practice." Here, programs leading to BCE, BEE, and BME degrees are offered. Each program requires four years of resident study for its completion.

MEMBERSHIP COMMITTEE CHAIRMAN William J. Lux has sent to his Committee — and to membership-interested folks in SAE Sections — some descriptions of "interesting specimens of members whom you may try to spot in your own haunts." Here they are:

1. **Big-Handed Joiner** — shakes hands very well. Always has a big smile and a friendly word for everyone. Probably on a liberal expense account and may have something good to sell.

2. **Shirt-Sleeved Committee Joiner** — a distant cousin of the Big-Handed Joiner. This one finds his way into committees of all sorts. Probably has a purpose for everything he does, and may have an ax to grind.

3. **Snoring Sleeper** — characterized by drooping eyelids and blank expression. Don't let this fool you. The Sleeper may be listening all the time, and he might come up with new ideas, born as a result of his isolation from the surrounding clamor.

4. **Grunting Pusher** — emits low groans and short sentences. Always behind some project or under some large load, so it is difficult to spot. Slow speed but large forces. Sometimes works in small groups on large problems.

5. **Arm-Swinging Crusader** — noisy and usually flapping their wings. These can be trained easily, and they love to perform. They make excellent Toastmasters and Public Relations men.

6. **Long-Fingered Investigator** — always looking for facts and details. May know very little about programs, but always has detailed knowledge of detailed steps. Asks many questions.

7. **Closed-Mouth Statistics** — these are like sparrows. There are more of them than of any other specie. Don't ignore them, though; they are valuable. With a little effort they become:

8. **Running Statistics** — these are the closed-mouth statistics who have developed distinctive and unique shades, colors, whistles, feather arrangements, or other identifying marks. This group is extremely valuable; each has his peculiar talent and, with proper encouragement, will make a worthwhile contribution.

9. **Leader** — to place an identifying adjective in this name is unnecessary. You will recognize him at once.

YOU'LL . . .

. . . be interested to know . . .

ELSEVIER'S NEW "AUTOMOBILE DICTIONARY" in eight languges (English-American, French, Italian, Spanish, Portuguese, German, Russian, and Japanese) draws heavily on SAE Handbook for standardized automobile terminology. Its preface is by an SAE member — Don Wilfredo P. Ricart, president of FISITA, . . . and its editor, in a paragraph on "language standardization" pays "high tribute" to the SAE for "fundamental work done before the dictionary was compiled."

D. Van Nostrand Company, Inc., Princeton, N. J., is distributor for the new dictionary in the United States.

FACTS . . .

. . . from SAE literature.

(SAE Journal will be glad to supply on request one copy of the piece of SAE literature described below. Address "Literature," SAE Journal, 485 Lexington Ave., New York 17, N.Y.)

HOW "SAE'S COOPERATIVE ENGINEERING PROGRAM Eases the Cost Squeeze on Industry" is described in a recently issued booklet under that title. It tells how results achieved by SAE Technical Committees return dividends to industry . . . reducing the cost of doing business and permitting greater returns on investment.

U.S. Can Regain 1st Place in World Markets . . . *IF*

by **Joseph E. Adams**

Vice-president, manufacturing and development, White Motor Co.

THE IMPROVEMENT in European know-how, plus wage differential advantage, is making itself evident throughout the world. American products were predominant in many countries before World War II . . . and immediately after. Now they are in second-best position.

Pride of workmanship has not yet been lost in Europe. "The Good Life" . . . the era of "I-am-entitled-to" an education, a job, a good life — *because* I am an American . . . has not yet become the sole ambition in Europe. There is still a lot of Horatio Alger philosophy in the minds of young people. In my opinion, we in the United States face continuing loss of markets unless we recognize certain fundamental factors.

We are not quite getting by in the face of European competition. But our objective must be to maintain our own standard of living while permitting the standards of living of the rest of the world to catch up with ours. At the same time, we must assist those areas in the United States which have a substandard of living to reach the privileged way of life that those in industry, both workers and managers, enjoy today.

Europe's need for things which we in the United States take for granted is great enough to take Europe's exploding economy through a period such as the early 20's here. This need for washing machines, refrigerators, television sets, etc., is in itself aiding Europe in its competition with us for world markets.

Our U. S. economy, on the other hand, must be expanded by increasing the buying power of our own substandard-living groups. We can do this only by:

1. . . . Stemming the constant inflation which decreases the standard of living of white-collared, retired, and similar groups — and puts no more real take-home pay into the pocket of the working man.

2. . . . By increasing our productivity substantially, by going to work and producing what we are capable of producing. Only thus can we reduce the actual cost of the product without reducing the standard of living of any person.

3. . . . By making it "right the first time" — so that our self-respect for quality is gained in the market places of the world.

"Going to work" applies to all levels of society in our country. We must be willing to pay for "the good life" or we can lose it. There is a real possibility that the so-called "Fabulous Sixties" can be a fooler; that our exploding population can be a millstone around our neck, dragging down our living standards as it has in other countries . . . unless we productively occupy our young people and get back a little of the Horatio Alger philosophy.

As the standard of living increases for the people of Western Europe, their take-home pay and their cost of living will also increase. Thus, gradually, competitive balance will be restored, making it possible for the United States to re-establish its position in foreign trade. Then, together with Western Europe, we can help to bring our standards of living to the under-developed countries of the world . . . providing we retain our initiative and drive by following the philosophy here outlined.

Economic-Political War

Khrushchev has said: "We declare war on you in the peaceful field of trade . . . the threat to the United States is not in the ICBM, but in the field of peaceful production. We think that capitalism should be destroyed — not by war and military conflict, but through ideological and economic struggle. . . . **We value trade less for economic reasons and most for political reasons.**"

This means still another stiff pressure on our U. S. exports, for Russia today has entered into the market place only on a hit or miss basis. Maybe Russia is just testing.

In any case, if we are not ready for competition with our friends who play the game with reasonable fairness, we can never be ready for competition which can sell its products at any price it wants in order to make a political point aimed at destroying our American way of life.

IF we will accept the philosophy that every American must recognize his responsibility to produce quality to the limit of his ability — and stop expecting that the world owes him a living because he is an American — and if we all accept the fact that a part of our American philosophy is not only an *opportunity* to work, but the *desire* to work with all the ability the Lord has given us, there is no doubt that the "Fabulous Sixties" can be just what they have been labeled.

Then, United States can regain its position in world markets, protect its home markets, and make a fantastic contribution to the American way of life. Thus we can help to bring a better standard of living to the rest of the world.

By being examples of industry and ambition, we can inspire others to follow the same path. By being examples of softness and laziness, we cannot help but suffer and leave the door open for greater foreign competition . . . and thus pave the way for Khrushchev's ideological and economic struggle.

It is the responsibility of each of us as Americans to do our individual part to protect the high standard of living and the freedom we have been privileged to enjoy.

We must be ready to pay for "the good life" with our honest efforts — or we can lose it. There is no choice!!

Joseph E. Adams

WHITE MOTOR's Joseph E. Adams has studied Europe's economic and manufacturing progress at first hand on several occasions in the last five years . . . and has been facing realistically the impact of that progress on foreign markets for American-built products.

Back in August 1958, he sounded a clear warning to American automotive manufacturers in an SAE Journal article titled: "Europe is Catching Up on Quantity Production Methods."

In this article, drawn from material in a dinner address to a recent SAE National Production Meeting, he presents a challenging philosophy of action, distilled from his continued thinking and exploration of this vital economic area.

SAE LETTERS FROM READERS

From:

C. L. Burton, Manager (M'52)
Development Division
Aluminum Company of America
Cleveland 5, Ohio

Dear Editor:

I am writing you regarding the article in the February 1960 SAE Journal entitled, "Brake Fade Rated by Engineering Yardstick" based on paper by Hykes and Herman of the Budd Co.

I have been disturbed by Fig. 3 (page 50), which shows an 11 point comparison between cast aluminum and cast iron as a brake drum material. I will make a few detailed comments.

1. Under cost per pound, aluminum is shown as six times more expensive than cast iron. Actually, a brake drum such as Buick uses, which contains 10½ lb of aluminum and about 5 lb of iron, can be produced for a little more than twice the cost of a conventional iron and steel drum. Also, it is a much superior drum as it extends the life of the lining by three times, and is much more resistant to fade than the iron drum. I can't think of any reasonable way in which the 6/1 ratio could have been determined.

2. The above comments carry over into the cost per cubic inch comparison and for the heat storage capacity, Btu per dollar.

3. Under heat conductivity, a ratio of 2/1 is shown in favor of aluminum. Actually, almost any aluminum alloy is superior in that respect by more than 2/1. The secondary alloy used by Buick in their drum has approximately three times more heat conductivity than cast iron, while the alloy in the new Pontiac integral hub and brake drum has 3½ times the thermal conductivity of cast iron.

4. The data under emissivity shows aluminum as having only 7.6% of the emissivity of cast iron. Actually, the materials would be about equal with a coat of dull black paint. Even a light coating of dirt would just about make them equal in emissivity. Emissivity is not an important factor in brake drums as has been pointed out in the body of the article.

5. The wear life of aluminum is shown as very poor in comparison with cast iron. However, there is a class of aluminum alloys containing large amounts of silicon which run very well against certain commercial lining materials. All production drums that we know of use thin cast iron liners.

I think much of the article is basic, although a number of brake engineers do not attach the importance to "steady state" that Budd does. I believe the only deterrent to the widespread use of aluminum brake drums is cost. As you know, even a slight amount of additional cost is a great deterrent to the use of any product on the American automobile. There are certain practical limits to the performance of passenger car drum type brakes when cast iron is used as the brake drum material. Unsprung weight must be limited and this places a ceiling on the performance of the cast iron brake drum. Organic linings are needed for smoothness which limits temperature. A better drum type brake can be produced by the use of aluminum brake drums then can be produced using only cast iron.

It seems to me that if the large American automobile is to have a substantial improvement in brake performance, it will very likely come by the use of aluminum brake drums. The drum type brake with its advantages could be retained.

The new aluminum integral hub and drum offered on the Pontiac car is just about impossible to fade and it performs well in all other respects. No iron brake drum remotely approaches it in fade resistance, and I don't' see how it could without some device such as water cooling, or the use of metallic linings which have other serious drawbacks.

● Since Mr. Burton has raised some issues which he feels need elaboration, may we elaborate also in the same order as in his letter:

1. Cost per pound . . .

Aluminum alloy pig may be delivered to our plant as of this date for $0.256 per pound. Cast iron pig, also delivered, costs $0.031 per pound. This is in the ratio of 8.25 to one. We used six to one in our paper to be safe.

In the Buick drum quoted by Burton, made of 10.5 lb of aluminum alloy and 5 lb of cast iron, at twice the cost of the replaced cast iron drum, the following may be of interest. The drum replaced, of cast iron with a steel drum head, weighed approximately 21 lb. Therefore:

$$10.5\ \text{Al} + 5\ \text{C.I.} = 2 \times 21\ \text{C.I.}$$
$$10.5\ \text{Al} = 37\ \text{C.I.}$$
$$\text{Al} = 3.3\ \text{C.I.}$$

The discrepancy between 3.3 to 1

From:

Maj. Gen. Yi-Fon Cheng
Commandant,
Air Cadet Flying School
Chinese Air Force
Republic of China

Dear Editor:

1. During the past one year, this school has continuously received 12 issues of your well-edited and beautifully published SAE Journal. SAE Journal is not only instrumental in enhancing the promotion of the officers' and students' technical know-how in the field of automotive engineering, but also provides instructors excellent reference material for instruction and training.

2. I, on behalf of Chinese Air Cadet Flying School, wish to take this opportunity to express to you my heartfelt gratitude.


空軍軍官學校

一、過去一年中本校經常收到 貴社惠贈 SAE
雜誌使本校官生士兵對現代汽車自動機
工程之智識獲益良多甚為感謝
二、謹特函申謝並希繼續惠贈無任企盼
此致
S.A.E.雜誌
中華民國四十九年

This is the original of the letter translated at left.

versus 8.25 to 1 occurs since a lesser weight of aluminum is required due to its higher heat conductivity and lower specific gravity.

2. The six to one ratio in cost per pound of aluminum versus cast iron is used throughout the remaining calculations in the paper.

3. Sources used in allocating heat conductivity to aluminum were believed to be reliable. However, they may have been out-of-date and they certainly were for primary aluminum. We accept Burton's correction.

4. Burton is correct. Figures shown, as indicated, were for as cast but oxidized material.

5. To our knowledge, even at this date, the high silicon aluminum alloys which show promise for use as a friction surface are still in the development stage. There is a question also in our minds as to whether the high silicon alloys will not have greatly reduced thermal conductivity.

The use of steady state testing procedures, as indicated in the original paper is just one more engineering yardstick which allows the industry to properly assign and measure the advantages accruing from changes in materials, designs and locations of brakes, drums or discs. Only by such procedures can "cut and try" development programs be eliminated.

We question whether those who promote and use aluminum have exhausted the alternative possibilities of drum design and brake location to solve their present problem. We do feel that our method of testing can point the way to further progress without the use of aluminum. Meanwhile, for the present and for the foreseeable future, the use of aluminum involves greatly increased cost.

Paul G. Hykes and **Clarence A. Herman**
The Budd Co.
Automotive Division
Detroit 15, Mich.

From:

William J. Lux (M '52)
Supervising Engineer, Research Dept.
Caterpillar Tractor Co.
Peoria, Ill.

Dear Editor:

The computer is a tool. Its characteristic abilities, speed, and accuracy, classify it as a general-purpose tool, which can be fitted with "programs" making it suitable for an almost infinite variety of jobs.

Consider the road builder in 1860. His animal horsepower was capable of building 1960 highways — if it had enough time. The ancient astronomers could locate the stars with extreme accuracy — if they had time to make the calculations. The traveler could visit every continent during his vacation — if his vacations were long enough. Years ago, scientists had all of the basic principles for putting a satellite into orbit, but they didn't have enough time to calculate the design and operational details of the rocket to put it there.

Power solved two of these problems and high-speed computers solved the other two. There seems to be little similarity between a missile and a highway, but the computer is proven to be useful in designing and building both.

Like the computer, most engineering processes have wide application when they are reduced to their basic elements. Can you imagine how many ideas are buried under the blanket of special application? Try reading about other fields of engineering — you will be surprised at some of the gems that are just waiting to be picked up by some curious, wandering explorer.

From:

V. C. Kloepper (M '16)
Automotive Engineering Consultant
St. Louis, Mo.

Dear Editor:

Please continue to list my name in the 1960 SAE Consultants list, which the Society publishes.

I know it will interest you to know that I have received several very interesting appointments through your Consultants list. I have through your listing been appointed chief consulting engineer for Diesel Nacional S. A., Mexico, where I spend considerable time.

From:

William J. Storey
Bradley University
2502 Court St.
Pekin, Ill.

Dear Editor:

I have accepted a position and wish to have my name removed from the SAE Placement Service list of 1960 engineering graduates (SAE Journal, December, 1959, pg. 103–108).

Although I did not accept a position through SAE, I received many letters affording excellent opportunities in the engineering field. I feel that for February graduates, the list should be published in an earlier issue — about October.

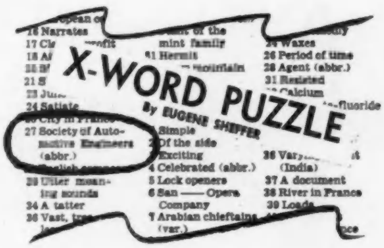
I understand that this was a pilot program, and I hope that it is continued for it opens the door to the many engineering opportunities available and not the few companies that are able to visit each school.

SAE in the NEWS

THE DUBLIN EVENING PRESS of Jan. 13 carried news of the election of Harry E. Chesebrough as SAE's 1960 president under the two-column headline "What Car Men Want to Do in the 60s."

The balance of the article quoted President Chesebrough's expectations of automotive advances in the decade ahead.

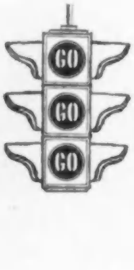
SAE MEMBER-CROSS-WORD-PUZZLE FANS would have no difficulty in filling in No. 27 across in the March 14 New York Journal American's puzzle. It was "27. Society of Automotive Engineers (abbr.)."



National

AUTOMOBILE

Week



Engineer must consider owner use and maintenance habits when designing cars and trucks

DESIGNING for specific user needs and whims was a major theme at SAE's National Automobile Week meeting. More than a 1000 engineers heard of design, material, and testing developments aimed at satisfying car and truck users.

Luncheon speaker J. N. Bauman, president of White Motor Co., called the fulfillment of this aim the "third dimension" of engineering and said that the engineer not only should design a product that the customer wants, but must also anticipate how the customer will use and maintain the product.

Some examples of designing for the driver brought out at the meeting were riding comfort, air conditioning, fuel economy, and automatic highway driving. Engineers heard of a seven-degree-of-freedom laboratory ride simulator that reproduces typical road motions in a car, thus helping the designer build in a comfortable ride. The advances in air conditioning vehicles were closely tied to the physiological reactions of driver and passengers, pointing the way to future developments. Also, the ways to get more out of a gallon of gasoline, for the same weight and power car, were described and evaluated.

A second theme that ran through the meeting was the advances in engineering materials. Latest developments in steels, plastics, rubber, and aluminum were brought out by a panel of experts. Following quickly were an analysis of structural adhesives as well as the solution of aluminum corrosion and gear metallurgy problems. Many of the discussions on these subjects were stimulated by new problems generated by compact car design.

The program for the meeting was set up under the leadership of J. H. Booth, chairman of the General Committee. B. W. Bogan, chairman of the Detroit Section, welcomed engineers to the meeting on behalf of the Detroit Section, which acted as host.

SAE National Automobile Week included:

Suspension Design for Single Unit Construction, **F. R. Kishline and T. M. Lawler, Jr.**, American Motors (**143A**).

Vehicle Dimension Effects on Noise and Vibration Control in Unitized Construction, **F. J. Hooven,** Ford (**143B**).

Control of Noise and Vibration in the Unibody, **J. R. Farnham**, Chrysler (**143C**).

Suspensions-From the Ground Up, **C. M. Rubly,** Chevrolet (**143D**).

Analysis and Simulation of Automobile Ride **R. H. Kohr,** GM Research Labs. (**144A**).

Structural Adhesives in Automobiles, **A. F. Thomson and A. F. Martin,** Minnesota Mining Mfg. (**145A**).

The Bodies in Which We Live, **W. H. Jackson,** GM Harrison Radiator Division (**146A**).

Progress of Automotive Heating Thru the Years, **H. V. Joyce,** Ford (**146B**).

Controlling the Automotive Air Conditioner for Comfort, **J. T. Kreasky,** Chrysler (**146C**).

Decorative Plated Coatings of Improved Durability, **D. M. Bigge**, Chrysler (**147A**).

Corrosion Considerations of Aluminum Automobile Engine Components, **A. M. Montgomery,** Alcoa Research Labs. (**147B**).

Case Hardenability of SAE 4028, 8620, 4620, and 4815 Steels, **J. A. Halgren and E. A. Solecki**, International Harvester (**149A**).

Practical Application of High Temperature Gas Carburizing, **O. E. Cullen**, Surface Combustion Division, Midland-Ross (**149B**).

Several Possible Paths to Improved Part-Load Economy of Spark-Ignition Engines, **A. E. Cleveland and I. N. Bishop,** Ford (**150A**).

A New Tool for Combustion Research, **F. W. Bowditch,** GM Research Labs. (**150B**).

Automatic Highway and Driver Aid Developments, **J. B. Bidwell, H. M. Morrison, G. A. Hanysz and A. F. Welch,** GM Research Labs (**151A**).

The Development of the Smiths Automatic Transmission for Rootes Group Range of Light Cars, **C. S. Steadman**, Smiths Motor Accessories Ltd., Whitney Works, England (**152A**).

Engineering Highlights of 25 Compact Cars, **J. R. Bond**, Road & Track Magazine (**152B**).

SAE Body and Chassis Frame Drafting Standards for the 1960's Plus Complete Set of Revised Standards, Ready for Inclusion in Existing Automotive Drafting Manuals . . . $2.50 to members; $4.00 to nonmembers . . . (**SP-176**).

Automobile Aerodynamics — A progress Report, **P. R. Kyropoulous, K. B. Kelly, William Tanner**, GM Styling Staff; A. H. Esper and J. F. White, Ford . . . $2.00 to members; $4.00 to nonmembers . . . (**SP-180**).

Papers are available through SAE Special Publication Dept. Prices. 50¢ a copy to members; 75¢ a copy to nonmembers. Special Publications are priced as noted in the listing.

FATHER AND SON, R. F. Kohr, Palmer Products Inc. (right) and R. H. Kohr, GM Research Laboratories (left), were active in session on GM's ride simulator. The elder Kohr, a past-chairman of the SAE Technical Board, was chairman of the session; the son presented a paper entitled, "Analysis and Simulation of Automobile Ride."

SAE PRESIDENT Harry E. Chesebrough (center) emphasizes point to SAE past-presidents Leonard Raymond (left) and William K. Creson (right).

LUNCHEON SPEAKER J. N. Bauman, president, White Motor Co. (right) meets with luncheon toastmaster James H. Booth, Thompson Ramo Wooldridge, Inc. (left) and SAE President Harry E. Chesebrough (center) at luncheon reception. Bauman spoke on "Third Dimension Engineering." Booth was general chairman of the Meeting. Not shown is B. W. Bogan, chairman, SAE Detroit Section, who gave the welcome address at the luncheon.

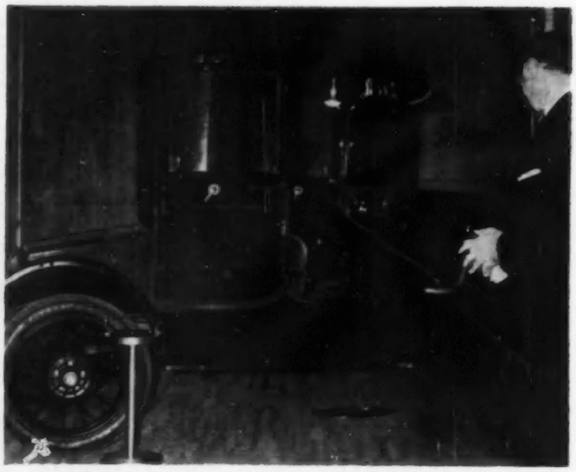
. . . More on SAE National Automobile Week→

SAE National AUTOMOBILE Week

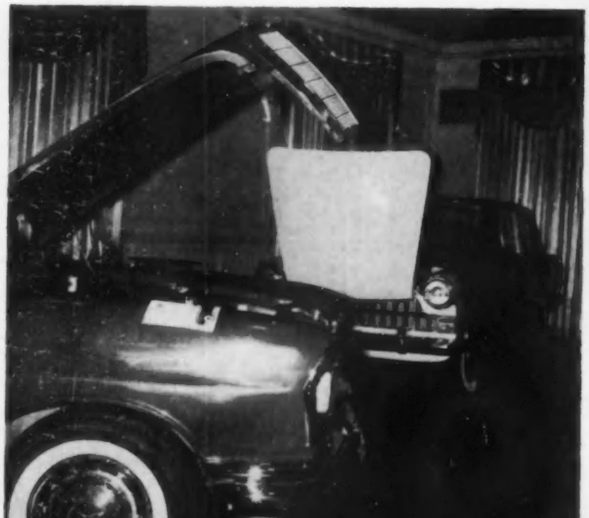
Continued

DIVISION 33 — GEAR METALLURGY SUBCOMMITTEE of Iron and Steel Technical Committee held meeting during Automobile Week. Harold J. Bates of Fairfield Mfg. Co. is chairman of the subcommittee.

CORVAIR REAR-ENGINE AND SUSPENSION DISPLAY aroused much interest at session on GM's ride simulator.



1919 FORD equipped with fresh-air exhaust-type heater was part of display showing automobile heater design over the years.



SAE MEMBER INSPECTS ENGINE of Fiat 2100 Sedan (rear). Mercedes Benz 220-S Sedan (foreground) also was displayed at Compact Car Engineering session.

Production Meeting

features:

- Aluminum casting.
- Tape-controlled machines.
- Cold forming.

Running close behind in top interest at the Cleveland Meeting were (1) design for efficient manufacture, (2) high energy forming, and (3) cost control.

TWO interest-compelling production headlines were written at the 1960 SAE National Production Meeting held in Cleveland on March 22–24:

• A tremendously important — and highly successful — forward step in aluminum casting has been taken by Chevrolet at its Massena (N. Y.) plant. Using a low-pressure, permanent-mold process licensed from a German firm, Chevrolet has made giant strides in the art of permanent-mold aluminum casting.

• Look for major advances in card, tape, and computer-controlled machines. A forecast was made that by 1965 more than 60% of all machine tools purchased would be equipped for tape control. Predictions were heard frequently in the lobbies that important technical breakthroughs are imminent. A production executive was heard to tell a customer, "Don't bother about the drawings — we can make it from the data we have!" In this case, the part was produced from a mathematical description, which was punched on a tape used to make a prototype. **This made it possible to produce and test a prototype part before the prints were ready.**

A curious thing about the Chevrolet-Massena plant is that the facts about the operation seem to be turned around 180 deg from the published reports. The essential facts, given at Cleveland for the first time, are as follows:

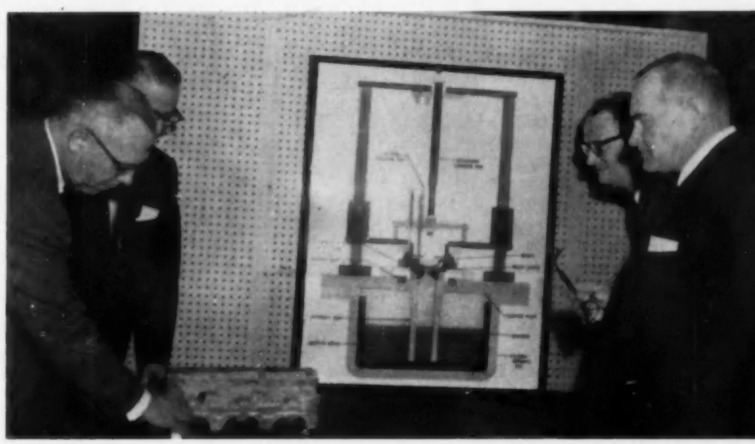
What public reports have said:

• Production per man-hour is low.
• Scrap losses in excess of 30% have been reported.
• Impregnation is frequently necessary.

The facts are:

• Output per man-hour is equal to or better than original estimates, although there have been production problems.
• Scrap range is 2–10%, depending on the casting.
• Impregnation is used on a single casting — the transmission case — because it is economical to do so. Porosity is *not* a major problem in the cylinder head casting, which does not require 100% X-ray inspection.

Probably the most significant comment made on the Massena operation was this: Chevrolet has crowded at least 10 years of operating experience into a single year at Massena. Qualified production men attending the meeting reported, for example, that the low-pressure process used at Massena has been expanded tremendously, compared with the original German process. Mechanization already exceeds by a wide margin anything attempted in Germany. While Chevrolet's use of automatic equipment is outstanding, the most important advance is in the area of controlling directional solidification. Much of the technical know-how being accumulated



THERE WAS INTEREST aplenty in the aluminum cylinder head for the Chevrolet Corvair displayed at the Cleveland meeting. In the background is a working model. Light air pressure applied to the metal surface forces the aluminum to flow upward in the center pipe, filling the mold.

THEY DID THE WORK — and SAE members were the beneficiaries. Shown at the left is P. H. Neville, general committee chairman. Mr. Neville is president of Leese-Neville Co., Cleveland. At the right is K. C. White, technical program chairman. Formerly a professor at Cornell University, Mr. White is now associated with Thompson Ramo Wooldridge, Inc.

will undoubtedly be adapted to improve die casting operations at Chevrolet plants.

Historical note contributed by a discusser at the meeting: Ford used a low-pressure method to produce aluminum castings *for the Model T*. Pressure was 1 psi (compared with 3–6 psi for Chevrolet.) Ford kept the air pressure on at all times. The operator covered the hole with his thumb when he wanted to apply pressure to the molten bath. Pressure was maintained for 5–10 sec. The Ford castings weighed only a few pounds, however.

The facts about Ford's use of cold forming reflect the extensive research and highly successful development work being conducted by Ford processing engineers. Ford is now producing production parts by cold extrusion in six plants. A single part — piston pins — has saved Ford 5000 tons of steel since 1955. Ford's output during this period is 40 million piston pins. Fatigue life of extruded pins is 51,000 cycles compared with 16,000 cycles for drilled pins.

Cold forming a truck wheel nut saves 500 tons of steel annually. Inexpensive hot rolled steel is specified instead of screw machine stock. A milling operation is eliminated.

Other cold-formed Ford parts include tappets, universal joint bearing races, automatic transmission gears, and tractor take-off shafts.

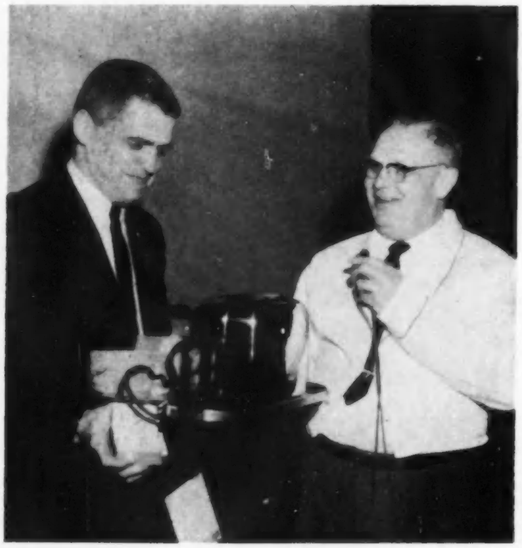
Ford process engineers see a remarkable future for cold forming:

"Cold extrusion and allied cold forming methods will ultimately capture a substantial portion of metal working tonnage. For small parts and automotive applications, the material and processing economies that cold extrusion affords must sooner or later take a heavy toll of competitive processes. For military items, the improvement in physicals without distortion is most attractive.

"Cold extrusion 10 years from now will be a process completely integrated with other steps necessary to produce a finished part from raw material. Many of the individual primary and secondary operations we know today will be either combined or eliminated. Probably we will go directly from cast metal into the cold forming press, or metal powder compacts may play an increasing part. Ultra-high-strength parts may be made right in the extrusion die without heat-treatment."

SAE President Harry E. Chesebrough told those attending the Wednesday evening dinner that the coming Annual Meeting at Cobo Hall in Detroit will undoubtedly surpass any similar meeting in SAE's long and colorful history. With virtually unlimited facilities available under one roof, technical programs unmatched for scope and quality will be presented. The possibilities for participation by leading European engineers are also excellent, Mr. Chesebrough said.

"LET ME THINK about that for a minute," J. E. Adams (left), executive vice-president, White Motor Co., and past-chairman, SAE Production Activity, tells SAE President Harry E. Chesebrough. A keen student of foreign affairs and recently returned from overseas, Mr. Adams spoke on the provocative subject, "America's Answer to Foreign Competition." We can meet the challenge from abroad, Adams told SAE members — but we'll have to work mighty hard at the job!



SAE SAW HIM SHIP this appliance home to Detroit so we know R. M. Nelson (left), Bendix Aviation Corp., winner of the Surprise Luncheon speaking contest, and Mrs. Nelson are having hot toast for breakfast each morning. The toaster served as a timer during the contest. Presenting the award is Toastmaster Howard A. Williams, Eaton Mfg. Co.

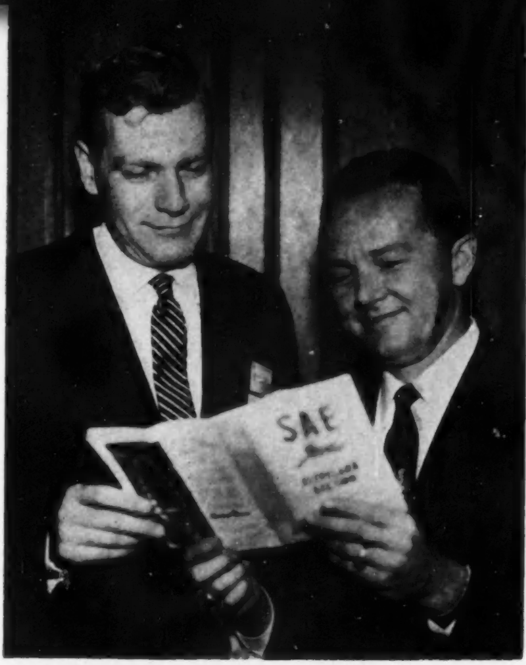
Principal speaker at the banquet was J. E. Adams, executive vice-president, White Motor Co. Mr. Adams spoke on the challenging subject, "America's Answer To Foreign Competition."

More than 50 persons accepted an invitation to visit Ford Lorain, newest and largest of Ford's 17 automobile and truck assembly plants. Visitors who were touring a unitized body-and-frame plant for the first time were impressed with such things as: (1) the interesting changes in assembly plant methods that have occurred in recent years, (2) the prominent role of materials handling and the decrease in the number of overhead conveyors, (3) movement of painting operations to the second floor of the building.

Following the tour of the 1,880,000 sq ft facility, Joseph A. Richardson, plant manager, answered questions for nearly an hour. At the conclusion of his talk he noted: "Developing dynamic human leadership is our biggest problem."

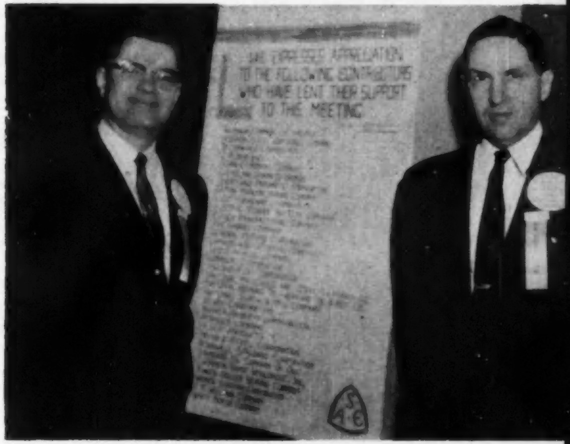
1960 SAE National Production Forum — SP-330

. . . includes reports on Aluminum Foundry Practice; Product Evaluation for Cost Reduction; Numerical Control of Machines and Processes; High Energy Forming; Automation in the Job Shop; Quality Control; Mfg. Processes; Materials Handling for Low-Cost Production; Standards for Control; Futures in Cold Extrusion; Management Development for a Mfg. Organization; Expense Control.
Price: $2 to SAE Members; $4 to nonmembers.



WELL PLEASED with the program planned for the 1961 National Production Meeting were E. H. Scott (left), chairman of the host Cleveland Section and Dr. Harry B. Osborn, Jr., Tocco Division, Ohio Crankshaft Co., who proved to everybody's satisfaction that a "toastmaster" can really liven up a dinner meeting.

THESE "HUMAN APPLAUSE METERS" judged the audience response to the extemporaneous remarks by the surprised speakers chosen to represent their table at the Surprise Luncheon on Tuesday. Can you think of something bright and witty to say on these subjects in 2 min or less: Should You Be Afraid of Your Boss? Why Should You Have a Male Secretary? How to Improve Relations between Engineering and Manufacturing? Left to right: J. L. Myers, Cleveland Graphite Bronze Co.; A. C. Schliewen, White Motor Co.; R. G. Hill, Leece-Neville Co.



YOU, TOO, would have had a friendly welcome from official greeters Harold Sanders (left), Pesko Products Division, Borg-Warner Corp. and W. S. Coleman, White Motor Co., chairman of the Publicity Committee.

News flashes from the Meeting . . .

● Titanium carbide tools containing 64% titanium carbide are now being run at speeds up to 1000 sfpm.

• Use of automatic equipment is growing rapidly — in defense, in large manufacturing plants, and even in the job shops. A development that may come along soon is setting up **computer and numerical control service establishments** for those who cannot afford to own the necessary equipment.

● Instead of processing cut sheets, a large manufacturer is now brush finishing in the coil, then cutting to desired length.

● A strong plea for improved metal finish standards was expressed during the meeting. A satisfactory method of finish evaluation would be welcomed, industry spokesmen told SAE members.

• Lorain assembly plant, home of the Falcon, Comet and Ford trucks, was built in record time. The first steel was received in October; cars were coming off the assembly line the following May. Now Ford's largest assembly plant, current output is 1200 units per day.

● A report picked up at the meeting (unconfirmed) is that *high energy forming is being used* by at least one car manufacturer for 1961 model prototypes.

• A careful study of handling and storage costs has convinced an eastern manufacturer that **use of air cargo shipments can greatly reduce plant inventories.** Costs studies showed that carload lot shipping savings were being eaten up by handling and storage costs.

● Computers are being used effectively *to determine conveyor loads.* A month's simulated production is put through a computer, enabling materials handling engineers to determine overloads, if any. Production schedules are then adjusted to bring conveyor loads in line with capacity.

• Ingenuity in loading refrigerators being shipped in box cars has resulted in substantial savings for an appliance manufacturer. Formerly, boxed units were shipped upright two high in railroad cars, leaving a large air space at the top of the car. **A special lift truck now lifts boxed refrigerators and slides them into horizontal position.** A vacuum cup arrangement attached to a special lift truck permits fast unloading at destination.

• If you're having supervision problems, console yourself with this:

At Ford's Lorain plant, 150 out of 173 foremen have had 14 months industrial experience or less.

Spacecraft and

are featured topics at SAE

THE NEXT DECADE IN AIR TRANSPORT should be a period of consolidation, improvement in service, and reliability, Sir George Edwards declared in his address given at the dinner on April 7.

He warned against the premature introduction of a supersonic transport, and the dangers to the free world of injecting it into the world's airline services before the operators were financially or operationally capable of absorbing it; or before there had been sufficient operating experience in the speed range and general design characteristics to enable passengers to be carried with safety. . . .

What he really wants to see happen, he said, is more responsibility toward achieving the overall goal of what is best for the traveling public in the world, and if to achieve this some of the ruthless competition has to go — let it go. . . . The pattern in Britain has changed so that twenty odd firms are now merged into five big groups. Sir George advocated this type of combining of efforts on a broad front.

Sir George Edwards (right) receives the Daniel Guggenheim Medal from Jerome Lederer, chairman of Program Committee, Daniel Guggenheim Board of Award.

Scott Crossfield, principal speaker, with Toastmaster Col. Fred J. Ascani before April 6 luncheon. Over 300 persons watched a movie on the X-15, and heard Test Pilot Crossfield describe its performance and potential. He said an advanced version could be put into orbit with a change in materials and a higher thrust.

SPOTLIGHT IS ON THE HEAD TABLE, as Sir George Edwards rises to give his address at the dinner held on April 7.

turbine transports

National Aeronautic Meeting

Luncheon Speaker Adm. William F. Raborn has a funny story for Toastmaster J. V. Miccio.

RUSSIA WOULD HAVE GREAT DIFFICULTY locating Polaris subs — and virtually all Russia is a target for the Polaris, Adm. William F. Raborn said in his April 5 luncheon talk.

He cited the following advantages to mobile sea launch sites:

(1) They are immune to surprise attack — can't be zeroed in ahead of time.

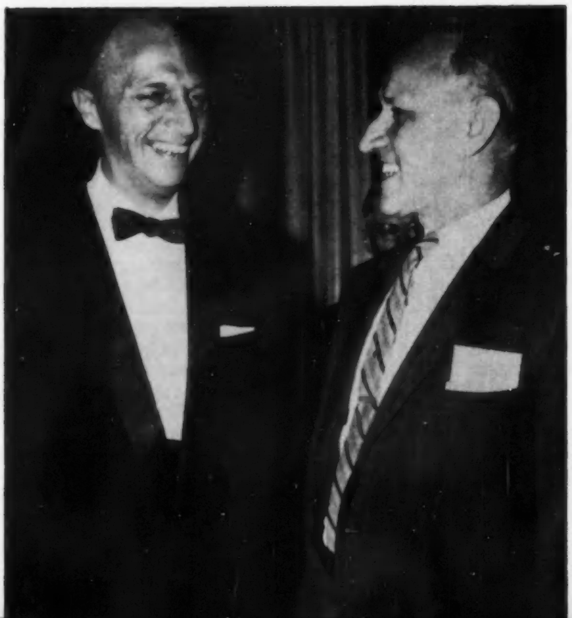
(2) They are available under constant 30-min countdown.

(3) They allow mature decision — prevent initiation of all-out war due to false information of ICBM attack.

(4) Silent mobility — they operate in free oceans.

(5) Low cost — Polaris sub has useful life of 15 yr.

H. H. Hanink (left) and J. D. Redding discussing details of Aeronautic Meeting. They headed committee which planned the meeting.



COMBINE over 2000 engineers, 33 technical sessions for paper and panel presentations, a missiles and aircraft display, and meetings of over a score of technical committees of the Society and the Coordinating Research Council. Spice the mixture with a behind-the-scenes tour of Idlewild, a liberal sprinkling of experts, and renowned guests speaking at two luncheons and a dinner. Mix well at the Hotel Commodore, New York City, and you have the cake-taking spring National Aeronautic Meeting, held April 4–8.

To be more specific about the ingredients:

• Technical sessions and panels covered transports — what the next generation will look like and solutions to problems of the current generation. Also discussed were spacecraft of the future, including their reliability, controls, and problems of men in space. Some of our weapon systems were talked about — with emphasis on reliability. And, manufacturing procedures necessary for modern aircraft and missiles were reviewed.

• There were two luncheons — one featured Admiral W. F. Raborn speaking on the Polaris missile, and the other, Scott Crossfield, who discussed the X-15 and his experience as test pilot of this experimental plane.

• Dinner on April 7 featured Sir George Edwards, principal designer of the Vickers Viscount, speaking on changing patterns in turbine transport. He was presented with the Guggenheim Medal for notable achievement in the advancement of aeronautics.

• Melvin N. Gough, famed test pilot and director of NASA activities at the Atlantic Missile Range, received the Laura Taber Barbour award for contributions to flight safety.

• Over 100 students attended the Student Engineers Night program.

The happy blend was planned by a committee headed by H. H. Hanink, Wright Aeronautical Division, and J. D. Redding, Remington Rand Univac Military Division. Hanink was responsible for production-engineering sessions, and Redding for sessions on design engineering and airline operations.

The Nuclear Congress, of which SAE is a sponsor, was held concurrently in New York. Sessions on nuclear-propelled space vehicles, components for nuclear-propelled space vehicles and aircraft, and nuclear-propelled air vehicles were also sessions of the Nuclear Congress.

William Littlewood, SAE past-president (left) and Harry Chesebrough, SAE President, find time to compare notes.

Mrs. Peggy Norris and Mrs. Doris Renninger, governor and secretary, respectively, of the New York and New Jersey Section of the Ninety-Nines (International Organization of Licensed Women Pilots), have an animated discussion with Herbert Fisher and Melvin Gough.

Walker L. Cisler (left), ASME president, and M. G. Beard, American Airlines, tell American Airline stewardess what a good job she did distributing corsages and boutonnieres to the ladies and gentlemen present at the April 7 dinner.

Melvin Gough (left) receives the 1960 Laura Taber Barbour Air Safety Award from Frazar Wilde. Gough is director of NASA activities at the Atlantic Missile Range; Wilde is president of Connecticut General Life Insurance Co., and retiring chairman of the Barbour Award Board.

This and that from the Meeting . . .

• REPLACEMENT OF CURRENT GENERATION of jet transports should be in the Mach 1.3-2 range. Mach 3 airliners would have to be new shape, made of welded steel sheet, and equipped with costly new engines. Flight testing of such an aircraft could cost as much as $60 million.

• BOOM produced by supersonic aircraft can be lessened by new design techniques. Noise comes from two waves — one created by the fuselage, and one by the wings. There is evidence that the wings and body of future supersonic aircraft can be designed so that the two waves tend to cancel each other.

• ROBERT E. JOHNSON WAS SURPRISED to find himself a "hero" at the Air Transport Activity Committee meeting. His registration lapel card, which should have read Wright Aero Division, had him located in the Wright Hero Division!

• NEW FABRICATION METHODS will be needed for hypersonic and space vehicles . . . present costs are extremely high. One possibility is that holes, rivets, joints may be eliminated in future designs.

• AN INTERNATIONAL FLAVOR was added to the meeting by a number of "foreign visitors." Among the visitors from outside the United States were: C. H. Jackson, C. Abell, and J. Romeril, of British Overseas Airways Corp., England; Bo Lundberg, Aeronautical Research Institute, Sweden; F. B. Greatrex and A. A. Lombard of Rolls-Royce, England; B. S. Shenstone of British European Airways, England; G. M. Lewis of Bristol Siddeley Engines, Ltd.; A. Pean, of Air France; R. D. Hiscocks, DeHavilland, Canada; J. T. Dyment, Trans Canada Airlines, Canada, and G. Berg of International Civil Aviation Organization, an Australian working in Canada.

• RUSSIA'S AIRCRAFT ACCIDENT RATE is bound to go up in the coming months. Reason: The Russians just don't have airplane accidents unless there's a foreigner abroad, or the plane crashes in foreign territory. Thus, since the number of tourists to Russia is increasing, the number of accidents reported will increase.

• S-62 SINGLE-TURBINE amphibian has been climbing the Himalayas, according to Miller Wachs, Sikorsky.

• STUDENT ENGINEERS NIGHT saw over 100 students tour the missiles and aircraft engineering display, attend a special student session at which they were addressed by E. J. Manganiello — associate director, NASA Lewis Research Center. He discussed how to keep up with trends in technology. After coffee and doughnuts, the students attended an evening session on nuclear-propelled space vehicles.

Student Engineers Night

STUDENTS examine mouse-sized high-altitude chamber during tour of display.

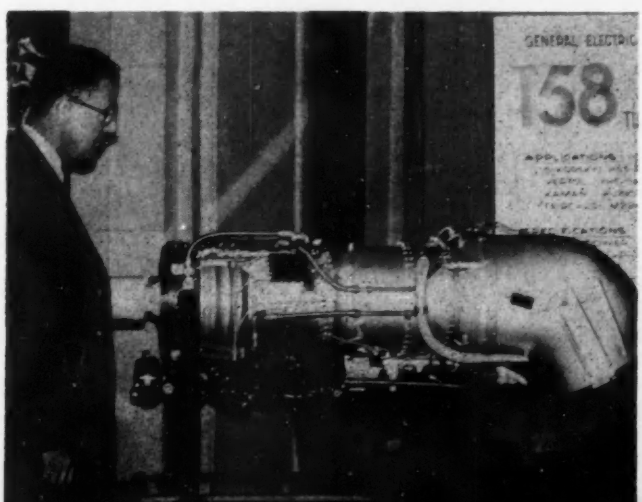
CONFERRING at Special Student Session are T. B. Rendel, Vice-Chairman, Students, Metropolitan Section (left), Mel Friedman, Chairman, CCNY Student Branch, and E. J. Maganiello, of NASA, who addressed the students.

Many points were made clearer at the technical sessions by means of displays. . . .

DESIGN PROBLEMS of integrating accessory power systems for future space vehicles were illustrated by a hypothetical glide vehicle.

Model illustrates problems in launching a space ferry from the earth's surface so as to MAKE CONTACT WITH AN ORBITING SPACE STATION.

T58 ENGINE was example of Navy turboshaft development.



GAS BEARINGS for airborne accessory equipment.

1960 SAE National Aeronautic Meeting included:

Selection of Accessory Power Systems for Long-Duration Manned Space Vehicles, **E. T. Raymond,** Aero-Space Division, Boeing **(154A)**

SNAP-2 — A Reactor Powered Turboelectric Generator for Space Vehicles, **Lt.-Col. G. M. Anderson,** U. S. Atomic Energy Commission **(154B)**

Heat Transfer Problems of Space Vehicle Power Systems, **Capt. R. A. Trusela and R. G. Clodfelter,** Wright Air Development Division **(154C)**

An Integrated Approach to the Planning, Evaluation, and Control of Capital Facilities, **C. W. Goldbeck,** Thompson Ramo Wooldridge **(155A)**

Reducing the Paper Mill Through Methods and Systems Simplification, **H. A. Helstrom, Jr.,** Chance Vought **(156A)**

Manufacturing Expense Controls, **R. M. Lynas,** Thompson Ramo Wooldridge **(156B)**

Basic Studies on Base Metal Thermocouples, **J. F. Potts, Jr.** and **D. L. McElroy,** Oak Ridge National Lab. **(158A)**

Materials for High (2500-4000 F) Gas Engine Temperature Measurements, **A. R. Anderson and D. J. MacKenzie,** Aero Research Instrument Co. **(158B)**

A Design Procedure for Thermocouple Probes, **L. B. Haig,** Research Labs., General Motors **(158C)**

Experimental Determination of Thermocouple Time Constants with Use of a Variable Turbulence, Variable Density, Wind Tunnel, and the Analytic Evaluation of Conduction, Radiation, and Other Secondary Effects, **A. F. Wormser,** General Electric **(158D)**

A Stable High Temperature Thermometry Rig, **R. J. Moffat,** Research Labs., General Motors **(158E)**

Intercomparison of Thermocouple Response Data, **F. R. Caldwell, L. O. Olsen and P. D. Freeze,** National Bureau of Standards **(158F)**
Dynamic Testing of Gas Sampling Thermocouples, **J. D. Meador,** Allison **(158G)**

Time Response Characteristics of Temperature Sensors, **M. D. Scadron,** Aero Research Instrument Co. **(158H)**

Engineering Standards for the Comparison of Direct Electrical Conversion Devices, **Lt.-Com. Frank Anders,** U. S. Navy Bureau of Ships **(159A)**

A Thermoelectric Air Conditioning Module for Sealed Cabins, **H. L. Hall and P. L. Catron,** Douglas — El Segundo **(159B)**

Thermionic Power Converter and Applications, **J. G. Leisenring,** General Electric **(159C)**

Fuel Cells — A Technical and Economic Study, **A. M. Moos,** Patterson-Moos Division, Leesona Corp. **(159D)**

A High-Temperature, Portable Fuel Cell Power Supply, **E. DeZubay,** Curtiss-Wright **(159E)**

Solar Concentration Cells, **B. H. Clampitt and D. E. German,** Boeing-Wichita **(159F)**

Applications and Limitations of Metal Removal Techniques in Aircraft and Missile Manufacturing, **Michael Field,** Metcut Research Associates **(160A)**

Production Application of High Energy Rate, **E. W. Feddersen,** Convair — Fort Worth **(160C)**

Explosive Forming, **E. F. Mellinger and F. A. Cox,** Ryan Aeronautical **(T39)**

Future Trends in Materials Removal Techniques, **M. E. Merchant,** Cincinnati Milling Machine **(T40)**

Theory and Application of the Plasma Arc, **R. M. Gage,** Linde Co., Division, Union Carbide **(T41)**

Process Refractometer for Continuous Plant Stream Monitoring, **D. D. Doran and Y. M. Chen,** Daystrom **(161A)**

New Developments in Air Gaging, **N. H. Sanderson and Max Knobel,** B. C. Ames Co. **(161B)**

Notes on the Results of Recent Tests of a Momentum Exchange Type Silencer for Turbojet Engines, **E. J. Stringas,** Curtiss-Wright **(162A)**

Design and Development of the General Electric CJ805-3 Thrust Reverser and Noise Suppressor, **W. S. Bertaux,** General Electric **(162B)**

Bypass Engine Noise, **F. B. Greatrex,** Rolls-Royce, England **(162C)**

System Test GSE for Modern Weapons Systems, **W. M. Alford and D. W. Cogswell,** Hamilton Standard **(163A)**

Boot-Strap Launching — A Step Toward Simplified GSE, **C. C. Worstell and W. A. Beck,** Boeing **(163B)**

Designing Hard ICBM Launching Sites, **W. R. Stumpe and M. V. Kadlick,** American Machine & Foundry **(163C)**

Acoustically Induced Fatigue — Cause, Solution, and Design Analysis, **E. W. Thrall, Jr.,** Douglas — El Segundo **(164A)**

Resonant Fatigue Failures Associated with Noise, **R. N. Bingman,** Wright Air Development Division **(164B)**

An Interplanetary Exploratory Vehicle, **W. E. Beall,** Boeing **(165A)**

Nuclear Space Vehicles Using Pebble Bead Reactors, **M. M. Levoy and J. J. Newgard,** Reaction Motors Division, Thiokol Chemical **(165B)**

Electric Propulsion and Power Requirements for Space Vehicles, **F. D. Stull and V. W. Shiel,** Wright Air Development Division **(165C)**

A New Design Approach for Supersonic Transport, **C. L. Blake,** Convair **(166A)**

Shock Wave Noise of Supersonic Aircraft, **I. L. Ryhming, Y. A. Yoler, and Y. Aoki,** Scientific Research Labs., Boeing **(166B)**

Supersonic Air Transports — An Airline Talks Back, **B S. Shenstone,** British European Airways **(166C)**

Nuclear Rakets for Lifting Manned Stations into Space, **H. F. Crouch,** Norair **(167A)**

Choice of Engine Type for Nuclear-Powered Multi-Purpose Aircraft, **D. P. Lalor and W. C. Schmill,** Douglas — Long Beach **(167B)**

Some Practical Methods for Fabricating Shields for Nuclear-Powered Aircraft, **W. Q. Hullings and J. L. McDaniel,** Convair — Ft. Worth **(167C)**

High-Temperature Materials for Solid-Propellant Rocket Engines, **E. L. Gray,** Utah Division, Thiokol Chemical **(168A)**

Ceramic Bodies and Coatings for Rocket Engine Applications, **W. T. Monagle,** Reaction Motors Division, Thiokol Chemical **(168B)**

Structural and Insulative Characteristics of Ablating Plastics, **J. L. Beal, G. A. Sterbutzel, N. E. Wahl, and F. A. Vassallo,** Cornell Aeronautical Lab. **(168C)**

Nuclear-Powered Airship, **Leo Jurich,** Goodyear Aircraft **(169A)**

Potential of Nuclear-Powered Aircraft for Commercial Cargo Transport, **J. F. Brady, Jr.,** Convair **(169B)**

Flight Reliability in Nuclear Aircraft, **L. W. Credit,** Martin **(169C)**

Trends in Navy Turboprop/Turboshaft Engine Developments, **Com. A. L. Rasmussen,** U. S. Navy BuWeps **(170A)**

The CL-44, a Breakthrough Cargo Aircraft, **K. H. Larsson,** Canadair **(170B)**

Aeroflot — Soviet Civil Aviation, **S. D. Browne,** W. H. Nichols Co. **(S235)**

Performance and Design Criteria of an Adaptive Circuit Proposed for a Space Re-Entry Vehicle, **W. E. Beauchemin,** Bell Aircraft **(171A)**

Minimum Flyable Handling Qualities of Airplanes, **Gifford Bull,** Cornell Aeronautical Lab. **(171B)**

Landing Aircraft Automatically and Reliably, **E. W. Velander,** Autonetics **(171C)**

Discussion of Some Design Problems Associated with Artificial Feel Systems of Airplanes With Irreversible Powered Flight Controls, **Tsun-Ying Feng and Donald Neil,** Bell Aircraft **(171D)**

The Turbofan Engine and Its Application Versatility, **S. M. Taylor and C. B. Brame,** Pratt & Whitney Aircraft **(172A)**

Aft-Fan Engines for Commercial Transports, **B. J. Gordon and R. C. Hawkins,** Flight Propulsion Division, General Electric **(172B)**

Turbofan and Bypass Type Engines for Jet Transports, **A. A. Lombard,** Rolls-Royce, England, and **D. Gerdan,** Allison **(172C)**

Man and Space, **Lester Carlyle,** Douglas — El Segundo **(173A)**

Human Engineering Payoff, **Maj. J. A. MacDonald,** Wright Air Development Division **(173B)**

Pilot Instrumentation for Vehicle Control in Near Space, **C. J. Hecker,** Sperry Gyroscope **(173C)**

A Comparative Analysis of V/STOL Types on a Payload-Range Basis, **John Aydelotte,** Boeing **(174A)**

Trends in VTOL Aircraft Propulsion System Requirements, **J. B. Nichols,** Hiller **(174B)**
A High Energy Absorption Landing Gear for VTOL Aircraft, **C. L. Wharton, Jr.,** Georgia Division, Lockheed Aircraft **(174C)**

Considerations of the Rendezvous Problems of Space Vehicles, **J. C. Houbolt,** NASA Langley Research Center **(175A)**

Adaptive Control Considerations for Re-Entry Flight, **J. H. Ahlberg and J. W. Clark,** United Aircraft Research Labs. **(175B)**

Recent High-Temperature Bearing Developments, **J. H. Johnson,** Marlin-Rockwell **(176A)**

Recent Developments in High-Temperature Bearings and Lubricants, **P. C. Hanlon,** Wright Air Development Division **(176B)**

Development Progress on Gas Bearings for Airborne Accessory Equipment, **C. R. Adams,** Aero-Space Division, Boeing **(176C)**

NASA Research on High-Temperature Bearing Problems, **W. J. Anderson and E. E. Bisson,** NASA Lewis Research Center **(176D)**

What Makes a High-Energy Propellant?, **John Clark,** U. S. Naval Air Rocket Station **(177A)**

Design Aspects of an Air Breathing Booster, **W. H. Bond and R. F. Mawhinney,** Convair **(177B)**

New Diet for the X-15 Engine, **C. R. Cramer and H. A. Barton,** Reaction Motors Div., Thiokol Chemical **(177C)**

Analysis of Problems of Oil Film Lubrication for Bearings Under Space Conditions, **Charles Apt and N. Wiederhorn,** Arthur D. Little, Inc. **(T42)**

Applications and Limitations of New Developments in Metals Joining Processes, **P. J. Rieppel,** Battelle Memorial Institute . . . $1.00 to members; $2.00 to nonmembers . . . **(SP-173)**

B-58 Reliability Program; **N. H. Simpson, R. E. Brady, R. D. Chase, B. M. Wall, J. L. Coburn,** Convair-Fort Worth; **W. J. Huber, E. Klosko, S. A. Rosenthal, W. J. Thompson,** Sperry Gyroscope Co.; **Gene Barnard,** Emerson Electric Mfg. Co. . . . $3.00 to members; $6.00 to nonmembers . . . **(SP-183)**

1960 New York Aeronautic Manufacturing Engineering Symposium . . . includes discussion on Facilities Planning and Introduction of New Products; Engineered Manufacturing Management; Reliability — Organization and Achievement; What's New in Manufacturing Methods; New Techniques of Measurement; and How to Manage and Control Manufacturing Research. . . . $2 to members; $4 to nonmembers. Available after June 10, 1960 **(SP-331).**

Papers are available through SAE Special Publications Dept. Prices: 50¢ a copy to members; 75¢ a copy to nonmembers. Special Publications are priced as noted in the listing.

AIR TRANSPORT ACTIVITY COMMITTEE meeting had solid "foreign" representation. Here, visitors to the United States pose with committee chairman Harold Hoekstra. Left to right: R. D. Hiscocks, C. H. Jackson, J. T. Dyment, C. Abell, B. S. Shenstone, Bo Lundberg, G. Berg, and Chairman Hoekstra.

Foreign members and guests exchanged ideas with U.S. engineers . . .

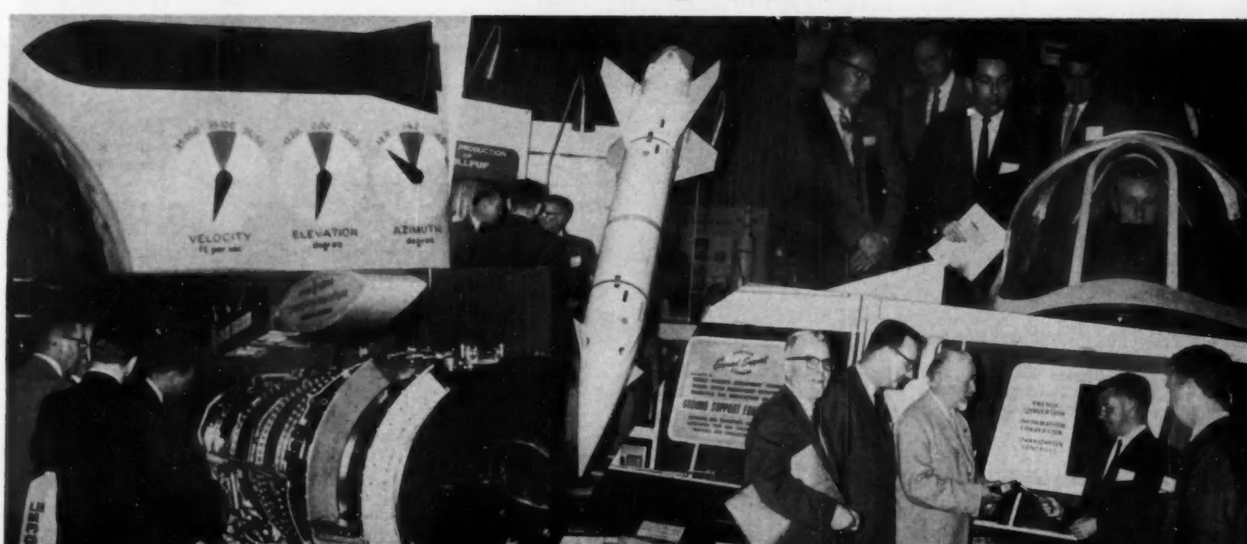
J. E. Davis of American Airlines (left) and A. A. Lombard, Rolls-Royce, discuss turbofan engines prior to session.

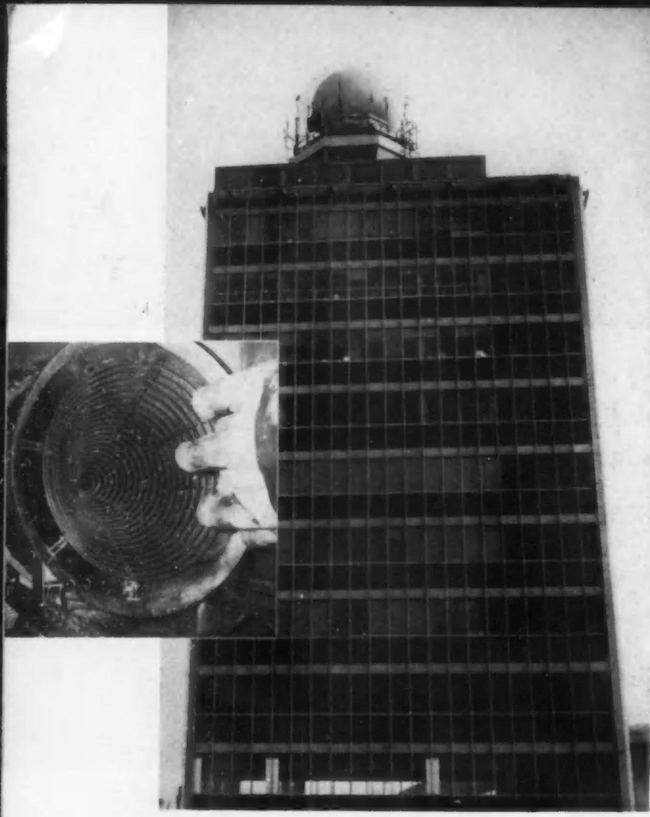
Dr. Arthur Nutt, SAE past-president, (left) chats with Bo Lundberg, director, Aeronautical Research Institute of Sweden.

John Romeril of British Overseas Airways (second from right) engaged in a pre-panel discussion with F. E. Tobin, R. P. Foster, and R. H. Bartlett.

F. B. Greatrex of Rolls-Royce, England (right) calls E. J. Stringas' attention to interesting point in paper.

At the Missiles and Aircraft Engineering Display . . .





STREAMLINED "SUPERMARKET" CHECKOUT COUNTERS in International Arrival Building. This system cuts customs processing time to 20 min or less for each incoming passenger — about half the time of former procedures.

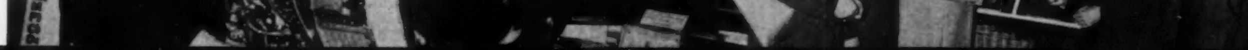
Behind-the-Scenes at Idlewild

Engineers inspect facilities on tour arranged by SAE Metropolitan Section as part of 1960 SAE National Aeronautic Meeting.

ONWARD to mezzanine overlooking lobby . . .

. . . CONTROL TOWER — 150 ft high — is seen in background.

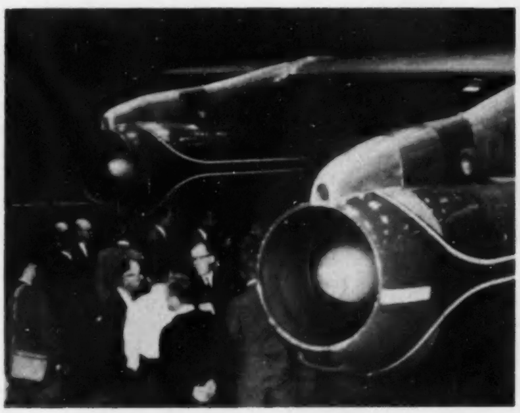
BOARDING PROCEDURES for overseas passengers were explained at Air France facilities. Planes are boarded via enclosed second-floor arcades in the Wing Buildings.

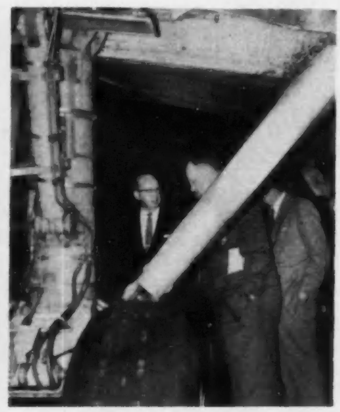


FAA AIR ROUTE TRAFFIC CONTROL center is beehive of radar screens, phones, charts, and fleet-footed personnel.

HIGH ALTITUDE space control is explained to tour group.

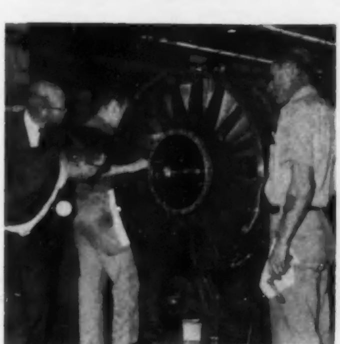
U. S. WEATHER STATION uses advanced techniques such as Radiosondes, which are sent up by balloon four times a day to an altitude of approximately 100,000 ft. These devices are sent aloft to evaluate vertical distribution of temperature, humidity, and pressure.



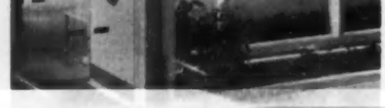


BOEING 707 was parked at American Airlines Hanger maintenance ramp. It was inspected outside . . . and in. Brief rundown on plane revealed that it can carry 15,516 gal of fuel.

OBSERVATION AND FORECAST PROCEDURES were explained. Little-known fact is that a 704 computer integrates the weather information for the Northern Hemisphere at half-hour intervals.



PAA JET ENGINE OVERHAUL SHOP was toured from initial dis-assembly to test cell. After 1200-1500 shop man-hr, the engine is ready for test — which averages 3 hr. Complete engine has approximately 7000 parts.



SAE MEMBERS

LEON F. DUMONT has a new assignment at Dupont in Wilmington. He has been made technical assistant in the "Freon" Products Division, working on technical aspects of market development, application, and sales of "Freon" fluorinated hydrocarbon solvents. Dumont, who is chairman-nominee for the Philadelphia Section for 1960–61, has been active in Section affairs ever since he joined Dupont some 12 years ago. His first work there was in research on interrelationships of fuels, oils and engines. Later he became project engineer working on chemical plant design problems — and then succesively was chief supervisor in the maintenance and construction division, the power division and the design division of Dupont's Plant Engineering Department.

L. I. WOOLSON, vice-president of Chrysler Corp. and formerly director of Chrysler's manufacturing staff and services, has been named manager of the newly formed Service Parts and Accesory Division within the Automotive Sales group. This division will combine the activities of the MoPar wholesale and dealer sales organization, and the service parts and accessory supply organization.

JOHN E. BRENNAN, vice-president and group executive, Chrysler Corp. Stamping and Chassis Parts group, has been appointed director of corporate manufacturing staff and services, succeeding **L. I. Woolson.** Responsibilities of the corporate manufacturing staff include manufacturing engineering, quality control, inter-plant transportation and plant protection.

CHARLES D. MANHART has become vice-president of Daystrom, Inc. and president of the defense Products group of Daystrom. Previously he was vice-president for government relations at Raytheon Mfg. Co.

WILLIAM A. McKINLEY has retired as board chairman of Midland-Ross Corp. He will continue as a director of the company.

McKinley has served Midland-Ross and its predecessor firms for 40 years. He was president and director of Midland Steel Products Co. before it merged with J. O. Ross Engineering Corp. to form Midland-Ross. At the time of the merger he was board chairman of Midland Steel Products.

ARTHUR J. WELCH has been elected president and general manager of Borg-Warner Corp.'s Spring Division.

Welch was elected a vice-president of the Spring Division in 1954. He served subsequently as vice-president and assistant general manager, vice-president and general manager, and, most recently, executive vice-president and general manager.

ALEX TAUB, out of retirement, is consulting engineer for Documentation Inc., pioneers in the information theory field.

LEWIS S. BEERS, formerly an engineer for The Martin Co., is now employed by the Missile and Space Vehicle Division of General Electric Co.

Beers was chairman of the April 5 session on Direct Conversion to Electricity — II of SAE National Aeronautic Meeting.

RALPH ISBRANDT, director of automotive engineering and research for American Motors Corp., has been elected chairman of AMA's Engineering Advisory Committee succeeding **Paul Ackerman**, vice-president, engineering, Chrysler Corp., Engineering Division.

ROBERT B. ROBINSON has become senior contact engineer for GMC Chevrolet Motor Division with headquarters at Buffalo, N. Y. Previously he was contact engineer at Flint, Mich.

ROY C. INGERSOLL, chairman of board of Borg-Warner Corp., has been elected a senior board member of the National Industrial Conference Board for a term of three years.

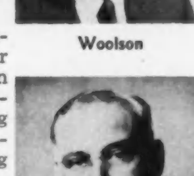
RICHARD S. WOODBURY has been appointed director of techno-economics research at Southwest Research Institute. Previously he was assistant to vice-president.

EARL E. KEARNS has become president of Private Air Travel, Inc. Formerly he was manager of metropolitan transportation for General Electric Co.

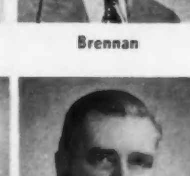
Dumont

Woolson

Brennan



McKinley



Welch



E. J. BLIGARD has been appointed manufacturing manager of MB Electronics, a Division of Textron Electronics, Inc. Formerly plant manager of the Machine Shop Division, Bligard joined MB in 1950 as an engineer on the design and development of engine vibration isolating mounts.

GERALD R. HOLLY has been named manager of sales engineering for Detroit Diesel Engine Division of General Motors Corp. In this position he will be responsible for the Division's application engineering function, product pricing, forecasting, order processing, and data processing.

He has been general supervisor of specifications and price analysis since 1959.

E. GILBERT MASON, president and general manager of Teco, Inc., has invented the "Mason Seat," a scientifically designed contour chair for airline passengers.

JAN LIYTTERLINDE has joined Yale & Towne Mfg. Co. as factory export representative for Africa and the Middle East. He will reside with his family in Johannesburg, South Africa. Previously he was product sales manager for Baker Industrial Trucks.

HARRY JOHN DELL, previously design engineer for Manufacturers Light & Heat Co., is now design and production engineer for Reeves Hoffman Division.


Bligard


Holly


Mason


Riblet


Williams

ROBERT M. RIBLET, chief engineer, Automotive Division, Timken Roller Bearing Co., has retired after 48 years' continuous service.

Riblet joined Timken in 1912 as draftsman in their Engineering Department. In 1918 he took charge of the company's engineering laboratory and two years later was appointed sales engineer for Tractor and Farm Implement Division of their Chicago office. In 1922 he returned to their home office as chief draftsman. He became assistant chief engineer, Automotive Division in 1934 and four years later was appointed chief engineer.

Riblet has played an important role in standardization of tapered roller bearing sizes on national and international levels. He is a past vice-chairman of SAE Cleveland section and has served on SAE Ball and Roller Bearing Committee.

ROBERT L. WILLIAMS succeeds **R. M. Riblet** as chief engineer, Automotive Division, Timken Roller Bearing Co. Williams joined Timken in 1938 as industrial sales trainee in the Engineering Department.

Subsequently he became sales engineer at Cleveland, district manager of industrial sales in Ontario, and district manager of industrial sales at Columbus, Ohio. Most recently he was assistant chief engineer, Automotive Division.

J. WILLIAM PUTT has become president of Encon, Inc. at Kingston, Pa. Previously he was assistant to president for Public Service Enterprises of Pa., Inc.

WILLIAM C. FUHLBORN, formerly manager of used car conditioning at Ken Ralph Lord, Inc., is now assistant service manager for George B. Dayle, Inc.

JOHN C. HAMPSON has been named vice-president, manufacturing and engineering at Northern Fibre Products Co. Previously he was general manager of Rockwell-Standard Corp.'s Research Division.

HERMAN L. COPLEN, JR. has joined Aerojet-General Corp. as principal engineer for nucleonics. Previously he was a member of the technical staff at Institute for Defense Analysis, Advanced Research Projects Agency at Washington, D. C.

HENRY B. HUTTEN has become supervisor of project administration for International Electric Corp. Previously he served General Electric Corp. as planning supervisor.

WILLIAM I. KARGELA, formerly senior design engineer, is now principal engineer for chassis section, Ford Motor Co.

RICHARD H. WHEELER has been named vice-president in charge of manufacturing at Warner Automotive Division, Borg-Warner Corp. His former position was works manager at Controls Division of Black, Sivalls & Bryson, Inc.

MARION F. THORNE has been appointed to the newly created post assistant to executive vice-president at Thompson-Ramo-Wooldridge, Inc. He will continue to serve as director of executive staff services for Ramo-Wooldridge Division.

ROBERT L. STANLEY, executive secretary of Diesel Engine Manufacturers Association, is secretary of the U. S. National Committee of CIMAC (International Congress of Combustion Engines), which recently announced that the next Congress will be held at Copenhagen, Denmark, in June 1962.

The theme of the Congress will be "Recent Developments With Diesel Engines and Gas Turbines Above 3000 HP and with Gas Engines Above 1500 HP." Anyone interested in presenting a paper at the meeting should send a resume to U. S. National Committee by December 15, 1960. For further information contact Stanley at 2000 K Street, NW, Washington 6, D. C.

The U. S. National Committee is sponsored by Oil and Gas Power Division and Gas Turbine Power Division of American Society of Mechanical Engineers. **JOHN C. GIBB**, of Socony Mobil Oil Co., chairman of Oil and Gas Power Division, is chairman of the U. S. National Committee, and **R. TOM SAWYER**, consultant, treasurer of Gas Turbine Power Division is vice-chairman.

B. E. COUNCIL has been named to succeed **Enos Cave** as assistant director of technical services at Continental Oil Co. Previously he served them as district manager.

J. E. GIECK, former member of sales engineering staff in Detroit, has been named Airide sales manager of Firestone Industrial Products Co.

W. H. CHASE, formerly plant manager for Clevite Corp., is now serving Lone Star Boat Co. in a similar capacity.

RAYMOND N. OKONSKI has become vice-president in charge of sales and plant operations for Dynamic Filters, Inc. Previously he was director of new product development at Michigan Wire Cloth Co.

DARREL M. VINCENT has been appointed chief engineer for Wayne Mfg. Co. He joined the company nine years ago as design engineer and was most recently assistant chief engineer.

(continued)

Little

Ladd

Chapline

Gregory

Shaver

Five SAE Members are connected with Ladd & Little, Inc., a newly formed company, with headquarters in Huntington Station, Long Island, N. Y., which will engage in international technological licensing and will arrange joint ventures abroad for medium and smaller sized firms.

The company has been formed by **MONTAGUE V. LITTLE**, who was general manager of Fairchild Engine & Airplane Corp.'s Al-Fin Division for 16 years, and **GEORGE T. LADD**, former chief engineer of Al-Fin Division.

GEORGE F. CHAPLINE, a former Fairchild vice-president and general manager of its Engine Division, will serve the company as associate on government relations.

DR. ALFRED T. GREGORY, former Fairchild director of research and engineering, is also an associate, specializing in the concept and design of propulsion systems.

WILLIAM A. SHAVER, manufacturers agent in Detroit, will handle liaison with automotive manufacturers in Mich. for Ladd & Little, Inc.

HOWARD L. ROAT has been appointed works manager of AC Spark Plug Division operations in Milwaukee. In this capacity he will direct AC-Milwaukee's manufacturing and related activities.

Formerly he was manufacturing manager of AC Spark Plug Division in Flint, Mich.

ALFRED B. THACHER has been appointed to the newly created position of manager of sales engineering for Hamilton Standard Division of United Aircraft Corp. Formerly he was Dayton representative for the division.

DAVID SCOTT ULLMAN, previously technical writer for Caterpillar Tractor Co., has become associate engineer with Denver Division of The Martin Co.

BARNARD BEVAN LEWIS, formerly field engineer in Los Angeles, is now field engineer in Seattle for Ethyl Corp.

ERNEST H. PANTHOFER, vice-president of Perfex Corp., has been elected a director of the company. Panthofer joined Perfex in 1941 and served them as chief engineer prior to becoming vice-president in 1954.

JAMES M. DILL has been appointed to the newly created position of special products sales manager for Russell, Burdsall & Ward Bolt & Nut Co. Dill joined RB&W as a sales representative in the Midwest in 1946 and was transferred to Port Chester, N. Y. headquarters in 1955.

GEORGE J. HAISLMAIER has been named general sales manager for the Automotive and Industrial Division of Modine Mfg. Co. A Modine veteran of 10 years, Haislmaier was appointed sales manager of Industrial Division in 1955 and was given added responsibilities as coordinator of automotive and industrial sales in 1957.

W. H. DAY has been appointed division sales manager — commercial for Shell Oil Co. Day joined Shell in 1937 as clerk for their marketing service. Subsequently he became head office representative, division engineer in Cleveland, and most recently industrial products manager in Chicago.

WILLIAM A. McCONNELL, manager of vehicles testing laboratory, Ford Motor Co., was recently awarded the honorary degree of Doctor of Engineering by the University of Nebraska.

GEORGE E. HERRMAN has been named manager of transportation sales at the Aluminum Co. of America. Herrman has been actively engaged in various transportation assignments for the past 20 years. He joined Alcoa as a sales engineer in the Detroit District Office in 1948.

CHARLES B. EISENHAUER has been named general manager of Electronics Division of Van Norman Industries, Inc. Formerly he was director of manufacturing at Continental-Diamond Fibre Corp.

RAYMOND S. VICKER has become European manager for the Wall Street Journal. In this capacity he will report European technical and industrial developments. Previously he was news editor.

THOMAS HARRISON RISK has become manager of materials, fuels and lubricants, department of engineering research at Ford Motor Co. Formerly he was manager of special product department at the Ford Division.

Dill

Haislmaier

Day

McConnell

Herrman

Eisenhauer

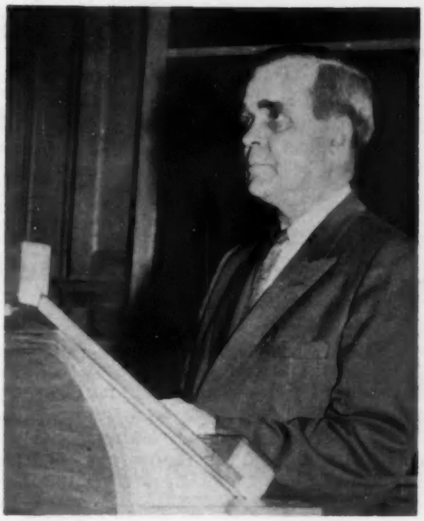
JAMES L. ROACH has been named vice-president and director of marketing at Wyman-Gordon Co. Roach joined Wyman-Gordon in 1939 and has served them as general sales manager since 1958.

GEORGE W. LA SALLE has been named vice-president in charge of engineering for Hercules Motor Corp. La Salle joined Herclues in 1928 and has been closely identified with its engineering and development activities. Most recently he was coordinator for the development of engines for use by the armed services and other governmental agencies.

ROBERT E. ZELL, general manager of Ingalls-Shepard Division, Wyman-Gordon Co., has been named a vice-president of the company. Zell joined the company in 1942, and was works manager before becoming general manager of Ingalls-Shepard in 1959.

JOHN D. HINTON has been named vice-president in charge of original equipment friction material sales at American Brakeblok Division, American Brake Shoe Co. Formerly the division's general sales manager, Hinton has been with Brakeblok for 17 years.

W. G. Lovell gives Clayton Lecture



WHEELER G. LOVELL, Ethyl Corp.'s research advisor, gave the James Clayton Lecture before a meeting of the Institution of Mechanical Engineers in London on March 1. "Some Chemistry of Future High Compression Engines" was his subject.

The Lectures originated through a fund provided by James Clayton, an IMA member, for the purpose of "encouraging mechanical engineering science" . . . and through which the Institution was empowered to invite distinguished engineers to give lectures on engineering subjects of their choice. A number of SAE members have been chosen since the inception of the lecture series in 1947.

ROBERT T. CURCURU has been appointed a vice-president of Pioneer Engineering & Mfg. Co., Inc. and general manager of their new Wettlaufer Mechanical Engineering Division. Curcuru was formerly head of his own research and design engineering firm. He was with Chrysler engineering for over 20 years, leaving there when he was managing engineer of advanced truck chassis design.

DONALD E. BUTLER, has been named vice-president in charge of sales at Royal Jet Division of Royal Industries, Inc. He is former vice-president and director of Airaterra and was vice-president for foreign licensing of Roylyn, Inc.

RALPH BERTSCHE, electrical engineer, GMC Truck & Coach Division, recently attended a meeting on international lighting standards in Rome, Feb. 29 to March 5 and a meeting of the working party of the Vehicle of the Economic Commission for Europe in Geneva March 21-25.

CARL J. BARBEE, attorney for Automotive Division of American Motors Corp., has been elected chairman of the Patent Committee of Automobile Manufacturers Association.

PETER KULKA, previously technical engineer for General Electric Co.'s jet engine department, is now equipment and methods engineer for their semiconductor products department.

CHARLES S. KOEGEL, formerly an engineer for Westinghouse Electric Corp.'s flight test section, is now an engineer for their electro-mechanical section.

FRANK BERRY is now a consultant on design and research of various hydraulic pumps. Previously he was employed by Berry Hydraulics of Corinth, Miss.

DONALD JAMES SUTHERLAND has joined Ford Motor Co. as body designer. Formerly he was senior draftsman at South Bend Division of Curtiss-Wright Corp.

PROF. EDWARD F. OBERT, professor of mechanical engineering at University of Wisconsin, has been named a member of a joint steering committee which will coordinate related programs at Lehigh University and North Carolina State for the strengthening of curricula in mechanical engineering through development of teaching and learning aids for laboratory instruction and for courses in design.

LAURENCE BALL, assistant chief engineer, car dynamics, Chrysler Corp., Engineering Division, was AMA representative to a meeting in Rapello, Italy March 29-31 of a group on instrumentation and procedures of technical committee 42 of the International Standards Organization.

WILLIAM C. SCHUSTER has been appointed fleet engineer with headquarters at Lancaster, Pa. for Perfect Circle Corp. Formerly he was district manager at Louisville, Ky.

(continued on p. 119)

Roach

La Salle

Zell

Hinton

Curcuru

Butler

SAE's CEP NEWS

COOPERATIVE ENGINEERING PROGRAM

Automotive Body Drafting Standards for 1960

COMMON industry practice is reflected in the 1960 revision of seven sections of the SAE Automotive Body Drafting Manual. Their improved format and incorporation into the Manual result from efforts of the Automotive Drafting Standards Committee to do three things:

- Report on, but not select, industry practices of *today*.
- Keep in focus the design-drafting relationship.
- Provide technical content of value to draftsmen and engineers in all areas of automotive work.

The sections affected by the 1960 revision and ultimately destined for inclusion in the Joint Aeronautical-Automotive Drawing Standards Manual are:

Car and Body Measuring — Gives a uniform method of measuring the interior and exterior of a car and its body. Use of this section will result in similar methods of car and body dimensions so that relative sizes, seating arrangements, and interior roominess may be compared and checked.

Body Draft Practice — Outlines drafting practices used in the design of automobile and truck bodies, fenders, hoods, and related sheet metal parts — methods which reflect today's manufacturing techniques.

Body Structure Practices — A direct and concise coverage of the salient points related to body structure practices used by both the body engineer and body draftsman, in four parts:

- Steps leading to the selection of the final clay model.
- Body frame and unitized construction concepts.
- Design details of body hardware installations and structural components.
- Definition of purpose and methods of bodies and bucks used to prove out an engineering design.

Automotive Body Terminology — Provides a glossary compiled to effect a better understanding of terms used in body design.

Body Mechanism — Classifies items which permit or generate motion by mechanical means, since body mechanisms are differentiated from structural and sheet metal parts by their function.

Body Silencing and Sealing — Covers various types of silencing and sealing materials and constructions generally used in the fabrication of automotive bodies. Materials used to insulate noise, heat, cold, dust, and water are described and illustrated.

Chassis Frames — Pertains to car and truck structure as related to design, interchangeability, rigidity, durability, and testing.

* * *

The sections listed above are available in loose-leaf form and may be inserted in existing SAE Automotive Body Drafting Manuals.

THE MOTIVATING FORCE behind the 1960 revision of the SAE Automotive Body Drafting Manual (shown at Wayne University's McGregor Memorial Center) consists of: Standing from left, R. S. Kellogg, Chrysler Missile Operations; J. W. McCauley, Chrysler Corp.; G. J. Gaudaen, SAE staff; R. D. Barrett, International Harvester Co.; Eric Lange, Ford Motor Co. Seated from left: E. R. Fitzpatrick, GMC Fisher Body Division; Prof. R. T. Northrup, Wayne State University; F. A. Lane, GMC Truck and Coach Division; J. M. Slessor, Ford Motor Co.; Automotive Drafting Standards Committee Vice-Chairman Harold Fisher, Bendix Products Division; Committee Chairman C. M. Wright, Chrysler Corp.; Douglas Love, SAE staff; R. L. Rice, Chevrolet Motor Division; J. H. Venema, Ford Motor Co.; Keith Epply, GMC Delco-Remy Division; W. G. Pierce, A. O. Smith Corp.

NEW WORK Ahead in '60's for SAE Technical Board Groups

▶ NEW standards numbering will cut distance between engineers and shop . . . Adapting man to new science-born equipment will get more study . . . So will international standards, Defense Department relations to industry-generated standards, and many new aspects of other existing areas of technical committee achievement.

By DR. ANDREW A. KUCHER

Chairman, SAE Technical Board

BY 1965, about 300 totally new SAE technical reports will have merged with some 1558 existing Society documents now in use by ground, air, and space industries. This prediction stems from a climate which indicates that SAE technical committee activity will continue to grow as it has since 1955.

The General Outlook

Man's physiological and psychological needs will play an increasingly more important role in technical committee work during the next five years. Physical tolerances and reactions, such as eye movement, will be the focal point of many foreseeable aeronautical and ground vehicle committee studies. Now under way is an SAE Riding Comfort Research Committee study of man's ability to resist shock and vibration. Similarly, aero-space committees are reviewing oxygen check-out procedures for air and space flight as well as problems encountered by inadvertent human exposure to high altitudes.

Ground Vehicle Committees

State and Federal agencies are depending more and more on technical guidance such as that contained in SAE standards. This will mean heavier emphasis on matters related to safe lighting practices, brake fluids, and the like.

A general expansion of the bulldozer, crane, shovel, and tractor industries has already been reflected in SAE technical committee work. And there is a good possibility of more to come. The need for standardization of such equipment has become increasingly evident with the growing use of mass production methods and testing techniques.

The recent Technical Board approval of a numbering system for all SAE ground vehicle reports will enable SAE to provide a better information dissemination service. This numbering system will definitely shorten the distance between engineering departments and shop facilities. It will also produce sounder understanding in user-producer contacts and remove excess verbiage in regulatory documents when SAE reports are referenced.

The need for international standardization will also be felt. More and more surface vehicles are crossing national boundaries every year. So, lights, brakes, and bumper heights are likely areas for standardization studies.

The Automobile Manufacturers Association has already established a permanent study group to monitor international standardization needs. This group expects to use SAE standards as documents on which to base automotive discussions.

Aero-Space Committees

Aero-Space committees are moving toward information development in depth. This is evidenced by the number of Handbook-type publications scheduled for release by SAE in the near future. For example, books on Applied Thermodynamics; Shock and Vibration; and Low Pressure, High Temperature, Pneumatic Ducting will soon be available.

The Defense Department recently released a document which permits Government contractors to use industry generated standards, such as those created by SAE. Here, for the first time, industry will be permitted the free use of hundreds of SAE standards and specifications to meet production and logistic requirements in military contracts. Although SAE standards were previously used by government contractors, each manufacturer had to get specific approval of their use.

Recent contacts with the SAE staff and General Orval Cook, president of the Aerospace Industries Association, indicate that AIA hopes to use the services of skilled engineering organizations, such as SAE, whenever these groups can satisfy the cooperative engineering needs of the aero-space industry. As technological requirements change, a gradual increase in the demand for this kind of SAE service is anticipated.

SAE aeronautical committees will continue to hold large meetings devoted to broad engineering subjects. This will bring together for an exchange of technical information men from all parts of the broadly distributed aerospace industry.

Conclusion

As the work of SAE technical committees continues to develop along established lines, it will continue to complement and supplement other important SAE programs, such as the SAE National Meetings, display activities, publication objectives, and others. It will also continue to serve as a means of introducing qualified men to Society membership.

Committee programs will continue to foster the needs of industry in the context of America's free enterprise system. These programs give industry engineers a maximum opportunity to serve as individuals.

SAE's CEP News

Cooperative Engineering Program

TACTICAL HELICOPTERS WERE VIEWED at close range by members of SAE Committee GSE-1, Military Support Equipment, during a 3-day meeting at Fort Rucker, Alabama, early this year.

From left in first row are: L. M. Shipley, Allison; M. L. Stoner, SAE Staff; P. T. Nelson, NORAIR; Brig. Gen. E. F. Esterbrook, Fort Rucker; A. B. Billet, Vickers; W. Kaufmann, Space Technology Laboratories.

Second row: GSE-1 Vice Chairman, R. G. Lohmann, Grumman; M. A. Stephens, Chance Vought; F. J. Liberman, Rocketdyne; H. H. Pfister, Rossford Ordnance Depot; K. E. Burham, Bell; David Mowrer, Boeing; R. E. Lenhart, McDonnell.

Third row: E. H. Roy, Sundstrand; W. A. Furst, Consolidated Diesel Electrical Corp.; S. B. Pfeiffer, Douglas; W. C. Stillman, Solar; W. A. Headley, Jr., Martin; J. P. Smith, Jr., Melpar; T. H. O'Brien, Brooklyn Polytechnic; T. H. Neighbors, Jr., Lockheed.

Fourth row: W. W. Toy, Vickers; J. W. Massey, Beech; Maj. C. I. Green, Brookley AFB; L. C. Barnes, Bendix Aviation; Cmdr. J. A. Laurich, U. S. Navy Bureau of Aeronautics; V. H. Bernardi, Office Director of Defense, Pentagon; S. C. Zeller, North American.

Fifth row: E. K. Kruger, Republic; GSE-1 Secretary, R. M. McClure, North American; S. DeStefano (behind McClure) and Col. J. W. Koletty, Army Transportation Supply and Maintenance; T. J. Wilson, Sr., Lear, Roth, Ft. Rucker; and GSE-1 Chairman, R. A. Taylor.

technishorts . . .

RESIDUAL STRESS AND FATIGUE — The Iron and Steel Technical Committee has expanded the scope of its Division 4 (recently designated Residual Stresses and Fatigue) to cover fatigue. This action will ultimately lead to the inclusion of fatigue information in the SAE Handbook. Division 4's current chairman is John Millan, Caterpillar Tractor Co.

C. J. JACOBUS, Yale and Towne Manufacturing Co., has been elected chairman of Subcommittee IX — Tractor Shovels of the Construction and Industrial Machinery Technical Committee. He succeeds J. C. Laegeler, Frank G. Hough Co., who has just completed a two-year term. This group is currently devising a new SAE Standard which has been designated, Specification Definitions — Industrial Tractor Front-End Shovel and Loader.

ROBERT SERGESON, Jones and Laughlin Stainless Steel Division, has been appointed chairman of a new subcommittee of the ISTC Division 14 — Alloy Steels. The Subcommittee's assignment is to explore the development of an alloy steel grade cross-reference table for possible inclusion in the SAE Handbook.

GEORGE CHIEGER, Fruehauf Trailer Co., succeeds the late B. Frank Jones as chairman of the Kingpin, Lower Coupling and Drawbar Connections Joint Subcommittee of the Truck and Bus and Transportation and Maintenance Technical Committees. At present, the Subcommittee is developing a trailer couplings standard for possible use in double-bottom operation on Thruways. It is also determining if the existing Fifth Wheel Kingpin Standard is adequate to handle the increased loads being carried on today's highways.

30 New AMSs Join SAE's Family of 874

THIRTY new documents have been added to SAE's family of 874 Aeronautical Material Specifications. Their issuance in January was tied to the revision of 41 existing AMSs, according to AMS Division Chairman N. E. Promisel.

A complete set of the new and revised AMSs is available in loose-leaf form to supplement those previously issued. Each set, along with a revised AMS Index, may be obtained from SAE Headquarters for $12.

New Reports

AMS 2248 — Chemical Check Analysis Limits, Wrought Heat and Corrosion Resistant Steels

AMS 2259 — Chemical Check Analysis Limits, Wrought Low Alloy and Carbon Steel

AMS 2269 — Chemical Check Analysis Limits, Wrought Nickel and Nickel Base Alloys

AMS 2301 — Aircraft Quality Steel Cleanliness, Magnetic Particle Inspection Procedure

AMS 2435 — Flame Deposition, Tungsten Carbide

AMS 2436 — Flame Deposition, Aluminum Oxide

AMS 3337 — Silicone Rubber, High and Extreme Low Temperature Resistant (65–75)

AMS 3380 — Hose, Polytetrafluoroethylene, TFE Fluorocarbon Resin, Wire Braid Reinforced

AMS 3656 — Polytetrafluoroethylene Rods and Tubes, Extruded, TFE Fluorocarbon Resin, as Sintered

AMS 3690 — Adhesive Compound, Epoxy, Room Temperature Curing

AMS 3691 — Adhesive Compound, Epoxy, Medium Temperature Application

AMS 3692 — Adhesive Compound, Epoxy, High Temperature Application

AMS 4056 — Aluminum Alloy Sheet and Plate, 4.5Mg-0.65Mn-0.15Cr (5083-0)

AMS 4057 — Aluminum Alloy Sheet, 4.5Mg-0.65Mn-0.15Cr (5083-H32)

AMS 4058 — Aluminum Alloy Sheet, 4.5Mg-0.65Mn-0.15Cr (5083-H34)

AMS 4059 — Aluminum Alloy Sheet and Plate, 4.5Mg-0.65Mn-0.15Cr (5083-H113)

AMS 4115 — Aluminum Alloy Bars, Rolled or Drawn, 1Mg-0.65Si-0.25Cu-0.25Cr (6061-0)

AMS 4117 — Aluminum Alloy Bars, Rolled, 1Mg-0.6Si-0.3Cu-0.25Cr (6061-T6)

AMS 4160 — Aluminum Alloy Extrusions, 1Mg-0.6Si-0.25Cu-0.25Cr (6061-0)

AMS 4161 — Aluminum Alloy Extrusions, 1Mg-0.6Si-0.25Cu-0.25Cr (6061-T4)

AMS 4224 — Aluminum Alloy Castings, Sand, 4Cu-2Ni-2Mg-0.3Cr-0.3Mn-0.1Ti-0.1V, Stabilized

AMS 4390 — Magnesium Alloy Sheet and Plate, 2Th-0.8Mn (HM21A-T8)

AMS 4444 — Magnesium Alloy Castings, Sand, 6Zn-1Zr (ZK61A-T5), Aged

AMS 4453 — Magnesium Alloy Castings, Investment, 9Al-2Zn (AZ92A-T6), Solution and Precipitation Treated

AMS 5509 — Alloy Sheet and Strip, Corrosion and Heat Resistant, 15Cr-45Ni-4W-4Mo-3Ti-1Al, Consumable Electrode Vacuum Melted

AMS 5734 — Steel, Corrosion and Heat Resistant, 15Cr-26Ni-1.3Mo-2.1Ti-0.3V, Consumable Electrode Melted, Annealed (1650 F)

AMS 5774 — Steel Wire, Corrosion and Moderate Heat Resistant, 16.5Cr-4.5Ni-2.9Mo-0.1N

AMS 7267 — Rings, Sealing, Silicone Rubber, Heat Resistant-Low Compression Set (70-80)

AMS 7278 — Rings, Sealing Synthetic Rubber, High Temperature Fluid Resistant, Fluorocarbon Type (70-80)

AMS 7279 — Rings, Sealing Synthetic Rubber, High Temperature Fluid Resistant, Fluorocarbon Type (85-95)

Revised Documents

AMS 2671B — Copper Furnace Brazing, Corrosion and Heat Resistant Steels and Alloys

AMS 2810C — Identification, Natural and Synthetic Rubber Materials

AMS 3150C — Fluid, Hydraulic, Fire Resistant

AMS 3274B — Synthetic Rubber Sheet, Nylon Fabric Reinforced, Aromatic Fuel Resistant

AMS 3302C — Silicone Rubber, General Purpose (45-55)

AMS 3303D — Silicone Rubber, General Purpose (55-65)

AMS 4125E — Aluminum Alloy Forgings, 1Si-0.6Mg-0.25Cr (6151-T6)

AMS 4171A — Aluminum Alloy Extrusions, 4.3Zn-3.3Mg-0.6Cu-0.2Mn-0.17Cr (7079-T6)

AMS 4766A — Brazing Alloy, Silver, 85Ag-15Mn

AMS 5643E — Steel, Corrosion Resistant, 17Cr-4Ni-4Cu

AMS 5510G — Steel Sheet and Strip, Corrosion and Heat Resistant, 18Cr-10Ni-Ti (SAE 30321)

AMS 5536C — Alloy Sheet Corrosion and Heat Resistant, Nickel Base, 22Cr-1.5Co-9Mo-0.6W-18.5Fe

AMS 5645G — Steel, Corrosion and Heat Resistant, 18Cr-10Ni-Ti (SAE 30321)

AMS 5646E — Steel, Corrosion and Heat Resistant, 18Cr-11Ni-(Cb + Ta) (SAE 30347)

AMS 5648C — Steel, Corrosion and Heat Resistant, 18Cr-13Ni-2.5Mo (SAE 30316)

AMS 5650A — Steel, Corrosion and Heat Resistant, 23Cr-13.5Ni (SAE 30309S)

AMS 5651D — Steel, Corrosion and Heat Resistant, 25Cr-20Ni (SAE 30310)

AMS 5652B — Steel, Corrosion and Heat Resistant, 25Cr-20Ni-2Si (SAE 30314)

AMS 5660A — Alloy, Corrosion and Heat Resistant, Nickel Base, 12.5Cr-6Mo-2.6Ti-34Fe, Consumable Electrode or Vacuum Induction Melted

AMS 5665D — Alloy, Corrosion and Heat Resistant, Nickel Base, 15.5Cr-8Fe

AMS 5667F — Alloy, Corrosion and Heat Resistant, Nickel Base, 15.5Cr-7Fe-2.5Ti-1(Cb + Ta)-0.7Al

AMS 5700B — Steel, Corrosion and

AMSs

. . . continued

Heat Resistant, 14Cr-14Ni-2.4W-0.4Mo

AMS 5736B — Steel, Corrosion and Heat Resistant, 15Cr-26Ni-1.3Mo-2.1Ti-0.3V, Solution Treated

AMS 5742A — Alloy, Corrosion and Heat Resistant, Iron Base, 20.5Cr-32Ni-1.1Ti

AMS 5754A — Alloy, Corrosion and Heat Resistant, Nickel Base, 22Cr-1.5Co-9Mo-0.6W-18.5Fe

AMS 5759A — Alloy, Corrosion and Heat Resistant, Cobalt Base, 20Cr-10Ni-15W

AMS 5768C — Alloy, Corrosion and Heat Resistant, Iron Base, 20Cr-20Ni-20Co-3Mo-2W-1(Cb+Ta), Solution and Precipitation Heat Treated

AMS 6304A — Steel, Low Alloy Heat Resistant, 1Cr-0.55Mo-0.3V(0.40-0.50C)

AMS 7210C — Cotter Pins, Steels, Corrosion Resistant, 18Cr-8Ni

AMS 7211A — Cotter Pins, Steel, Corrosion and Heat Resistant, 18Cr-9.5Ni-Ti

AMS 7452G — Bolts and Screws, Steel, Alloy, Heat Treated, Roll Threaded

AMS 7454B — Bolts and Screws, Steel, Low Alloy Heat Resistant, Normalized and Tempered, Roll Threaded

AMS 7455B — Bolts and Screws, Steel, Low Alloy Heat Resistant, Hardened and Tempered, Roll Threaded

AMS 7456E — Studs, Steel, Alloy, Heat Treated, Roll Threaded

AMS 7470D — Bolts and Screws, Steel, Corrosion Resistant, Heat Treated, Roll Threaded

AMS 7472G — Bolts and Screws, Steel, Corrosion Resistant, Roll Threaded

AMS 7476C — Bolts and Screws, Steel, Corrosion and Heat Resistant, Roll Threaded

AMS 7478C — Bolts and Screws, Steel, Corrosion and Heat Resistant, Heat Treated — Roll Threaded, 1800 F Heat Treatment

AMS 7479B — Bolts and Screws, Steel, Corrosion and Heat Resistant, Heat Treated — Roll Threaded, 1650 F Heat Treatment

AMS 7488A — Rings, Flash Welded, Aluminum and Aluminum Alloys

AMS 7490D — Rings, Flash Welded, Corrosion and Heat Resistant Austenitic Steels and Austenitic-Type Alloys

Rambling . . . Through The

CHEVROLET TRUCK ENGINE is discussed by Garth Sayers (right) of GMC Central Engineering, Chevrolet Division, at **INDIANA SECTION'S** March meeting.

THE GAS TURBINE'S HIGH OUTPUT per lb of engine was pointed out by Jim Hoadley from Bradley University as the Bradley team debated with the University of Illinois on the gas turbine as the future power plant for ground vehicles, at **CENTRAL ILLINOIS SECTION** March 21. Linn Peterson from the U. of I. rebutted by mentioning temperature limitations of the gas turbine.

The Bradley team, which won by 11 points, was presented with a trophy by (left to right) K. J. Fleck, section student chairman and H. R. Moos, assistant student chairman. Team members included Jim Furlong, Dick Vernon, Jim Hoadley, Jack Carter, and John Goad.

Sections

BAKING OVEN PROCESS, part of the two-toning utilized by Ford is observed at **METROPOLITAN SECTION'S** tour of Ford Mahwah February 18 by (left to right) Harry V. Chioffe of Ford Division and Maurice B. Rice of Chrysler Division, Chrysler Corp. (co-chairman of the Ford Mahwah tour.)

EDUCATION OF AUSTRALIAN ENGINEERS is slanted toward a large amount of shop experience. Because of this and because of a shortage of parts the Australians are masters at improvisation when it comes to repairing machinery, John W. Page, who was chief engineer of Caterpillar Tractor Co.'s Melbourne Plant during its first few years of operation, told **CENTRAL ILLINOIS SECTION** March 21.

GLASS TODAY includes some 600 useable types made from 30 elements; whereas for about 5900 years prior to the latter part of the 19th century limeglass, a product of five elements, was used — chiefly for ornamental purposes.

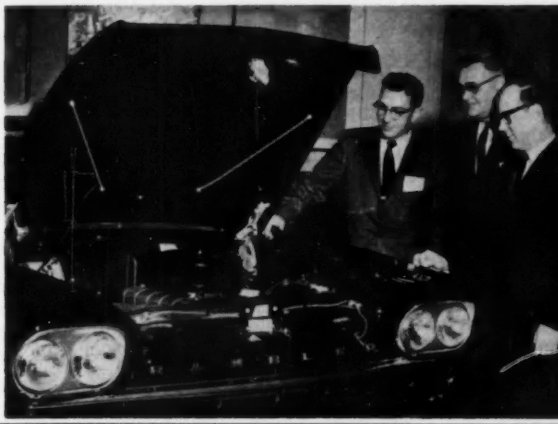
Pyroceram, an opaque crystalline ceramic material used for nose cones of rocket missiles, is a glass type close to tool steel in hardness. Vycor, a 96% silica glass, is comparable with quartz in physical properties and performance. Its low coefficient of thermal expansion enables it to withstand an instantaneous temperature change of over 900 C, George W. McLellan of Corning Glass Works told **SOUTHERN NEW ENGLAND SECTION** March 2.

DON'T use a standard bearing if you have to use a Rube Goldberg device to make it work — use a special bearing — Howard Yarbrough of Kaydon Engineering Corp. told **WESTERN MICHIGAN SECTION** March 1.

HAUL-PAK OFF HIGHWAY TRUCK, designed by LeTourneau-Westinghouse, has independent hydrair suspension to cushion road shocks. A short wheelbase and power steering provide extreme maneuverability, while high capacity is obtained by using a deep body which gives a low center of gravity, Ralph Kress of LeTourneau-Westinghouse Co. told **CENTRAL ILLINOIS SECTION** at their February meeting.

SMALL CAR DESIGN thinking has as many sides as the number of manufacturers supplying the market, concluded a panel of small car experts who discussed engineering problems involved in designing the compact car at **MID-MICHIGAN SECTION** February 1. Augmenting the discussion was a display of new compact cars on the market.

The Valiant (at left), one of the five cars displayed at the meeting, is inspected by some of the 240 members present.



The Rambler engine is discussed by (left to right) Harold Sieggreen, of GMC Central Foundry Division, Paul Moss of Saginaw Division, Eaton Mfg. Co. and Sven O. Wahamaki of American Motors Corp.

Ramblings • • •

Through The Sections

— continued —

FOR articles based on material drawn from Section papers in this issue see:

p. 86 . . .
. . . from a **CENTRAL ILLINOIS** paper
p. 86 . . .
. . . from a **SOUTHERN CALIFORNIA** paper
p. 86 . . .
. . . from a **METROPOLITAN** paper

SPECIAL RACING TIRES, used on the Thompson Challenger I, which set four new speed records at Bonneville Salt Flats last year, were smooth and made of nylon cord with only .025 inch of rubber tread. A tubeless tire design was used to eliminate the weight of inner tubes.

The weight of the car was 4500 lb. Air force caused by the high speed increased this weight to approximately 1000 additional lb air load. The car was driven by four counter rotating engines giving 1200 hp.

Top speed of the Challenger I was 367 mph, E. E. McMannis, chief racing tire design engineer at Goodyear Tire & Rubber Co. told **SOUTH TEXAS GROUP** February 29.

OFFSHORE DRILLING RIGS, designed by R. G. LeTourneau, Inc., have power equivalent to a crane with a boom 3 miles long and can lift a load of one ton, Tom Emerson of LeTourneau reported to **BRITISH COLUMBIA SECTION.**

THE MOON'S SURFACE, except for major topographical deformations, is indicated by radar studies to be relatively smooth. It is thought that on the average it has a two inch cover of dust, Dr. Robert Jastrow of Goddard Space Flight Center told **KANSAS CITY SECTION** February 25.

ENGINEERS SHOULD NOT be awed by the analog computer, but should realize what it can do for them and, thereby, use it more as a tool in their daily encounter with engineering problems, Howard Moss of Caterpillar Tractor Co. told **CENTRAL ILLINOIS SECTION** February 29.

RADIOISOTOPES, obtained by bombarding various materials in a nuclear reactor, are being used increasingly as companies realize their value in solving problems in research and development, W. P. Evans of Caterpillar Tractor Co. told **CHICAGO SECTION, SOUTH BEND DIVISION** March 21.

Radioactive Carbon 14, for example, has proved very useful in determining the diffusion of carbon in case-hardening processes. Prosphorus 32 can be diffused into metal, making it possible to determine the wear of a surface in considerable detail, instead of the more conventional method of measuring the amount of radioactive debris in the crankcase, which provides only an overall measurement of wear.

ASPHALTIC CONCRETE — an entirely different material from the old type of black surface that became slippery when wet — provides the best skid-resistance of possible highway surfaces, according to John C. Mackie, state highway commissioner, who spoke at **MID-MICHIGAN SECTION** March 14. Concrete, however, provides a close second, and both are being used in Michigan's vast highway expansion program.

ROCKETS IN THE 13TH CENTURY were used by the Chinese to fight the Mongols. Simple rockets, propelled by gunpowder, they proved very effective psychologically, terrifying the Mongol horses in the field, Ellis Levin of Boeing Airplane Co. told **SALT LAKE CITY GROUP** February 29.

SAE Section Meeting

SPOKANE-INTERMOUNTAIN

June 18 . . . "Ladies Night." Members, wives and guests welcome. Flamingo Cafe and Safari, N. 5005 Division, Spokane, Wash. Social Hour 6:30 p.m. Dinner 7:30 p.m. $7.00 per couple.

SAE National Meetings

- **June 5–10**
  Summer Meeting, Edgewater Beach Hotel, Chicago, Ill.
- **August 16–19**
  National West Coast Meeting, Jack Tar Hotel, San Francisco, Calif.
- **September 12–15**
  National Farm, Construction and Industrial Machinery Meeting (including production forum and engineering display), Milwaukee Auditorium, Milwaukee, Wis.
- **October 10–14**
  National Aeronautic Meeting (including manufacturing forum and engineering display), The Ambassador, Los Angeles, Calif.
- **October 25–27**
  National Transportation Meeting, Hotel Leamington, Minneapolis, Minn.
- **October 31–November 2**
  National Powerplant Meeting, Hotel Cleveland, Cleveland, Ohio.
- **November 3–4**
  National Fuels and Lubricants Meeting, The Mayo, Tulsa, Okla.

SAE Members

— continued from p. 111 —

WILLIAM M. HOLADAY, chairman of Civilian-Military Liaison Committee to the National Aeronautics and Space Agency and Department of Defense, spoke May 6 at the Seventh Annual Conference for Engineers and Architects at Ohio State University on "The Engineer in the Missile and Space Age."

A. E. KIMBERLY, of Chrysler Corp.'s Engineering Division, chairman of the Committee of 100 for Engineering at Ohio State, also spoke at the Annual Conference for Engineers and Architects at Ohio State.

KENNETH G. SCANTLING has been appointed superintendent, transportation section at Duquesne Light Co. Scantling has served Duquesne since 1940, when he was employed as junior engineer. Since then he has been automotive engineer and maintenance supervisor.

ROBERT B. BUTLER has joined Oscar E. Eggen & Associates as sales engineer. Previously he was employed by Sargent Engineering Corp. as industrial sales manager.

ELMER ANDERSON, formerly service manager, Service Engineering Department of Timken Roller Bearing Co., has been named service manager, domestic and international.

EARL N. PEARSON has been appointed sales representative for the Detroit area for Motor Wheel Corp.'s Automotive Division. Previously he was assistant sales manager for Thompson Products, Inc.

JOSEPH G. MACEYKA has become assistant plant manager for Wiedemann Machine Co. Previously he was chief engineer for H & M Tool & Machine Co., Inc.

Scantling

Butler

Anderson

Pearson

DAVID K. WIRTH has been named manager of Detroit Yale industrial lift truck and tractor shovel Sales and Service Branch of Yale & Towne Mfg. Co.

Wirth has been associated with Yale Detroit Branch since its founding in 1955. The majority of his time has been spent in the development of the national automotive accounts program. Prior to joining Yale he was president of Michigan Materials Handling Corp.

RAHLAND C. ZINN, vice-president, Lockheed Aircraft Service, Inc., received the Gold Knight Management Award of Greater New York Area Council of the National Management Association March 19 at the Association's 14th annual management conference. NMA criteria for the award includes leadership in good management practices in business and civic affairs.

RICHARD C. KERR has become chief scientist for Transportation Corp., U. S. Army. Kerr was employed by Standard Oil Co. of Calif. from 1925 to 1957. Since 1957 he has been a consultant on logistical and transportation problems to U. S. Army and to oil and mining industries.

LOUIS PETER COSGROVE has become senior engineer for support systems at Lockheed Aircraft Corp.'s Missiles & Space Division. Previously he served Goodyear Aircraft Corp. as lead engineer for missile support systems.

ERVAN EDWARD SIEGRIST, previously an administrator in the central engineering department, is now administrative assistant for research and development at Rockwell-Standard Corp.

FRANK A. SHARPE, retired director of sales for Universal Friction Materials Co., continues to be an active engineer, retaining his contact with trade sales and engineering personnel. An original member of the Old Timers Club, he has been invited to join his old company in a consulting capacity.

Obituaries

ALAN S. DUFF . . . (M'59) . . . director and sales manager for Hafner Fabrics of Canada, Ltd. . . . died March 1 . . . born 1904.

ALLEN C. KAISER . . . (M'52) . . . chief test engineer for gas turbines, Utica Division, Curtiss-Wright Corp. . . . died February 28 . . . born 1922.

NOEL H. MILLER . . . (M'27) . . . western sales manager, Automotive Division, Modine Mfg. Co. . . . died March 15 . . . born 1904.

OWEN D. PREMO . . . (M'55) . . . machine & tool engineer at S & D Engineering Co. . . . died November 12 . . . born 1903.

ANOTHER NEW PRODUCT OF C/R

BULLETIN SS-100

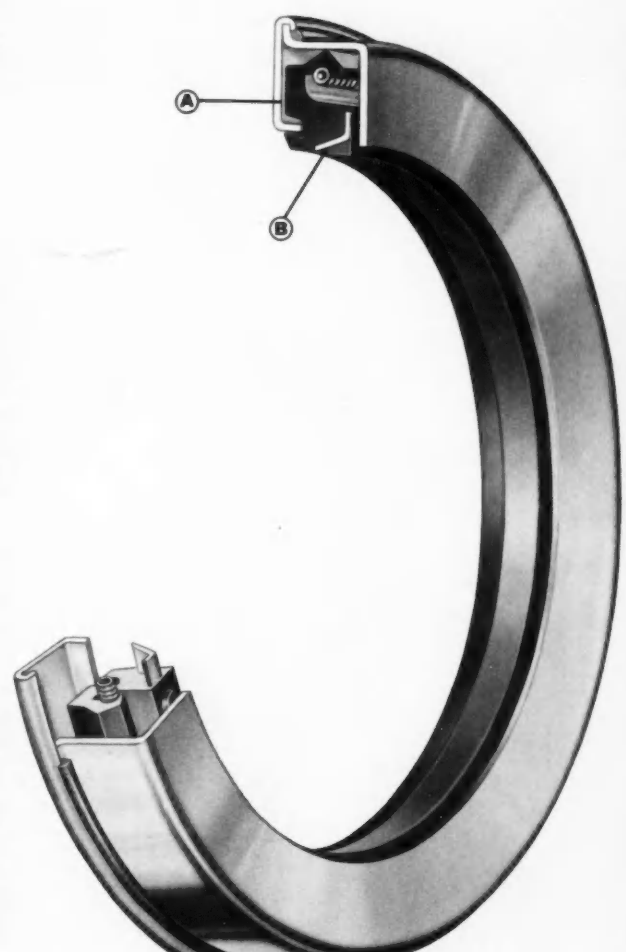
SCOTSEAL*

A new concept in oil seal design!

Integral sealing surface prevents major causes of leakage

It is now generally recognized that major causes of leakage among shaft type oil seals are: improper handling before assembly, damage by the assembler or shaft during installation, and improper shaft finish. Experts say surface finish of from 5 to 15 microinches is most desirable—but this is often prohibitively expensive.

The C/R SCOTSEAL precludes any possibility of damage by handling, installation, or shaft finish because the *sealing lip does not touch the shaft!* C/R's development of SCOTSEAL's integral, self-contained sealing surfaces assures you of reliable performance unsurpassed by the finest machined shaft surfaces.



HIGH PERFORMANCE OPERATION
Field tests have shown that this new C/R SCOTSEAL:

- SEALS WITH GREATER EFFICIENCY
- RUNS COOLER WITH LESS FRICTION
- DELIVERS GREATLY INCREASED SERVICE LIFE
- ELIMINATES SHAFT SCORING
- PREVENTS SEAL LIP DAMAGE AT ASSEMBLY
- REDUCES ASSEMBLY AND REPLACEMENT COSTS

UNIQUE DESIGN The C/R SCOTSEAL is designed and constructed to seal within itself. In effect it is a self-contained oil sealing cartridge. This sealing cartridge consists of two parts which have relative motion to each other. In the illustration above, the outer Unit (A) is an encasing member. A portion of the inner surface of this shell serves as the surface against which the sealing member runs. The inner unit (B) is the metal reinforced, bonded synthetic rubber sealing member. In the external design, illustrated, the sealing member pushfits over the shaft and becomes a part of it—actually moving *with* it—and the metal case or shell pressfits into the housing bore. On internal designs, the sealing surface pushfits on the shaft and the sealing member is contained in the shell which pressfits in the bore.

PRE-LUBRICATED Since the sealing element is enclosed, prelubricant applied during fabrication stays in place and lubrication is supplied to the sealing lip through centrifugal action, giving extra protection particularly during starved conditions. Where the seal will be exposed to considerable dirt and water, a dirt lip is provided. Also, drain holes can be provided in the shell adjacent to the dirt lip. Centrifugal force will then sling dirt and water out . . . keeping the C/R SCOTSEAL as free as possible from abrasive elements.

ECONOMICAL Significant savings or cost reductions can be realized with the C/R SCOTSEAL. Where normal lip-type seals ideally require a shaft surface finish of 5 to 15 microinches and minimum hardness of Rockwell C30, no special finish or hardness is required for the SCOTSEAL. Shafts need not be specially hardened, ground and polished over the area where the seal contacts the shaft. Nor are wear sleeves shrink-fitted on the shaft required. All of these operations are eliminated when the C/R SCOTSEAL is used. The savings in machining costs alone will more than offset the slightly higher first cost of the seal. And there is no possibility of lip damage in installation. Additional dependability and quality will accrue to your assembly in the minds of the end-user. There will be no scored shafts to remove and refinish. Replacement of the SCOTSEAL, if necessary, is a quick, simple procedure. Thus, equipment downtime and maintenance costs will be reduced.

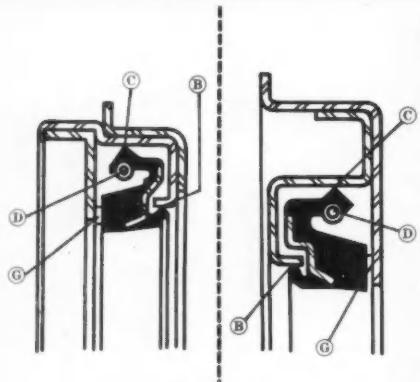
APPLICATION The C/R SCOTSEAL is currently providing increased sealing efficiency and extended service life on truck, bus and trailer axles. Its advantages indicate application wherever a high production run is involved; where oil retention is difficult; and where equipment downtime and replacement costs are critical. In broad terms, the SCOTSEAL may be used wherever an oil-tight press is possible.

(SEE ILLUSTRATIONS ON OTHER SIDE)

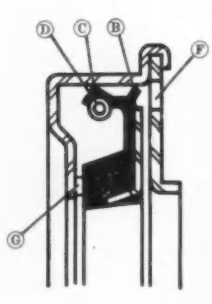
* Self Contained Omnipurpose Type SEAL. Trade Mark

Shaft Type Scotseals...

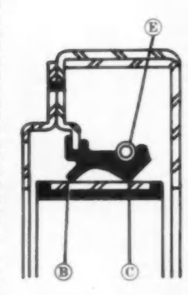
The versatility of the basic C/R SCOTSEAL concept is illustrated below. Note the many different configurations, as well as material combinations, that can be developed, all embodying the self-contained principle, but fitting ideally the requirements of various applications.



External Type SCOTSEALS

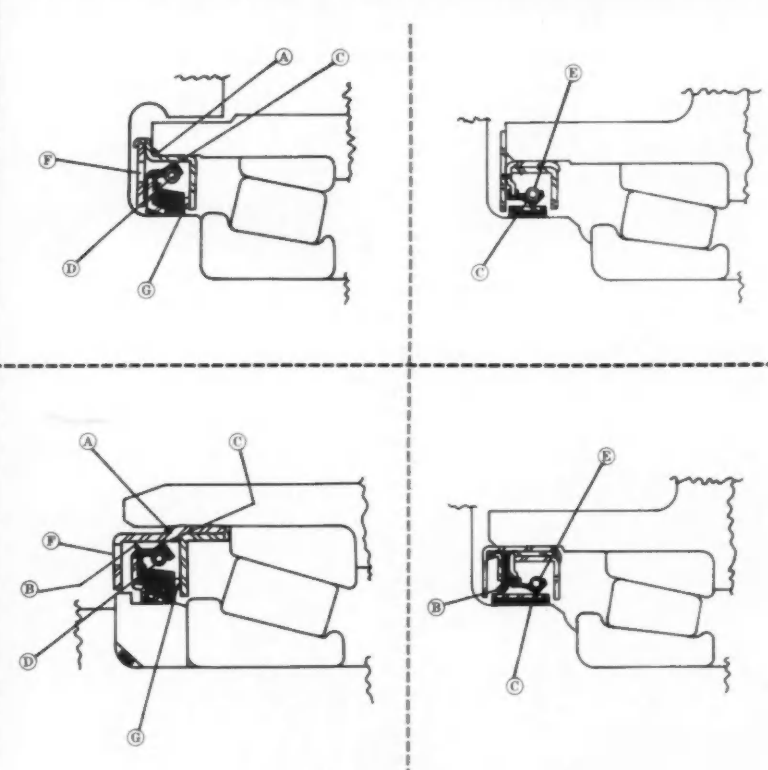


External



Internal

TYPICAL INSTALLATIONS... SEALING BEARINGS



LEGEND: **(a)** Sirvene Gasket **(b)** Dirt Lip **(c)** Sealing Lip **(d)** Expanding Spring **(e)** Contracting Spring **(f)** Drain Hole **(g)** Chaplets—keep sealing element spaced axially within its shell to insure proper installation.

Investigate this seal further. It will reduce costs for you and the ultimate user of your equipment where large production quantities are involved, and leakage, downtime and replacement are critical factors. C/R Oil Seal engineers will gladly recommend the correct C/R SCOTSEAL design for your application. Get in touch today.

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120-Kva Constant-Speed Drive Has Fabricated Housing

Based on paper by

P. C. MOSHER and
L. B. HALLBERG
Sundstrand Aviation

FABRICATED HOUSING — made by brazing or welding precision castings, forged flanges, and a rolled shell — is a feature of the Sundstrand 120-kva hydromechanical constant-speed drive. All components are stainless steel.

This technique saves space, increases strength, and reduces differential expansion compared with aluminum or magnesium castings. . . . And it has these additional advantages:

- Materials used permit operation at temperatures of 1000 F or more.
- Assemblies can be made from two or more different materials, if desired.
- Design changes can be made by removing sections and welding or brazing new ones in their place.
- Salvage or repair of defective housings can be accomplished.
- Thin sections that can't be cast can be welded to thicker sections.
- Good corrosion-resistant properties are attainable.

Package Requirements

The constant-speed transmission had to fit into a space essentially 12 × 12 × 12 in. Transmission should mount on an AND 20006 Type XVIC 10-in. bolt circle, and pad on the waist gearbox of a P&W JT3D turbofan engine. A suitable quick-attach-detach coupling is to be used for mounting the generator to the transmission. Transmission has to support entire overhung moment of the 155-lb generator.

Problems to Be Solved

Fabricated housing solved the following problems . . .

Magnesium or aluminum housings are generally used for the temperature range of – 65 F to + 300 F. But for this application, a light metal casting would have to be large and bulky to support the required overhung moment of more than 3000 lb-in. statically. The package limitation wouldn't permit the bulky housing.

Secondly, heavier loads of the pump wobbler would not allow use of aluminum or magnesium without additional support or extremely heavy sections.

Third consideration was the differential expansion between the steel bearing races and the housing. Motor wobbler outer ball bearing race — 9 in. in diameter — would expand approxi-

(continued on p. 127)

(continued from p. 124)

mately 0.020 in. less than a magnesium housing over temperature range of − 65 F to + 275 F. A heavier bearing race securely fastened to the housing would tend to reduce the housing expansion, but would result in an increased running clearance of the bearing.

Techniques and Materials

Housing design makes the various pieces to be joined self-fixturing during the brazing process — producing better dimensionally controlled structures than could be produced by fixtures.

Fixturing is required for tack welding. But after tack welding, the housing is removed from the fixture to permit completion of the welding process. This method results in a cleaner weld and minimizes distortion of the fixture due to repeated heating and cooling.

Furnace brazing is used instead of torch brazing to minimize distortion and warpage throughout the structure. Brazing filler materials were evaluated and AMS 4777 filler metal was selected.

All components are made of AISI 347 (SAE 30347) stainless steel.

Precision castings are used for complex items such as control cylinder, filter, basic governor, limit governor, and pressure switch housings. Complexity of these items make their manufacture from bar stock impossible. Furthermore, precision castings aid in keeping weight to minimum because 0.062-in. walls are cast successfully.

One flange is sand cast because its large diameter isn't within present precision casting capabilities. Three flanges are forged, premachined, and welded to a cylindrical rolled shell.

Required oil passages between components consist of stainless steel tubing brazed in place.

To Order Paper No. 128F . . .
on which this article is based, see p. 6.

Plastics Improved With Nuclear Radiation

Based on paper by

JOHN J. GREBE and DAVID E. HARMER

Nuclear and Basic Research, Dow Chemical Co.

CHEAPER and stronger plastic materials may be produced through the action of nuclear radiation on suitable monomers and polymers. Through such processes, the desirable characteristics of one plastic material may be added to another by producing a chemical graft of one material to the other.

Dyeability, printability, and surface characteristics of polymers may be modified so that new combinations of plastic covering materials should soon be commercially available. By way of example, highly fluorinated polymer films (Teflon or Kel-F) are well known for their unusual physical properties, such as solvent and heat resistance. At the same time, this very inertness creates problems when it is desired to dye the material or print patterns on it.

If the material is, however, placed in a suitable liquid monomer and radiation is introduced, a chemical reaction occurs at the surface which forms a "graft" of new polymer across the entire surface. If the monomer (from which the new polymer is formed) is chosen correctly, dyeing or printing of the surface is now easily accomplished.

It should be noted that the layer of new polymer which has been formed on the surface is not a mere physical coating; it is a chemically bonded part of the original film that cannot be removed short of actual destruction of the film. Thus, the desired physical properties of the original film are maintained while to them has been added additional useful properties of the second polymer.

To Order Paper No. 123A . . .
on which this article is based, see p. 6.

Briefs of SAE PAPERS

(continued from p. 6)

F. E. MARSH. Paper No. 141A. Summary of techniques as formulated and used by Boeing Airplane Co., Aero-Space Div., in manufacture of missiles; set-up of organization for reliability control; example of application of reliability controls through typical product life; customer requirements; layout and detail design; reliability assurance controls.

FAA Certification of Turbine Transports, HAROLD HOEKSTRA. Paper No. S230. Discusses the work of the Federal Aviation Agency in certification of turbine transports. Covers the certification process, some of the problems encountered, the results obtained in service, and an estimate of future transport trends. Lists turbine transports approved to date, and turbine transports for which applications for certification are pending.

Aeroflot — Soviet Civil Aviation, S. D. BROWNE. Paper No. S235. Discusses organization, missions, and equipment of Aeroflot, the official Soviet airline, and its predecessors. Aeroflot's missions cover: air transportation; air services for agriculture, forestry, and other branches of the national economy; geodesic and cartographic services; scientific investigation; medical services; and cultural, educational, and sports. Contains table comparing Soviet turbojets and turboprops with Western powerplants, a map showing Aeroflot air routes, and many illustrations of Russian planes.

GROUND VEHICLE

Correcting Horsepower Output — Realistic Method for Diesel Engines, A. K. BLACKWOOD, W. J. McCULLA. Paper No. 121A. Paper refers to progress report of SAE Test Code Committee presented at meeting June 1958, indexed in Engineering Index 1958, p. 292; concepts of correcting power output of diesel engines for variations in ambient test conditions are clarified and correction method, modes of application, and limitations are described; actual engine test data are given to support its adoption.

Universal Means for Rating Diesel Engines for Deposits and Wear, F. A. ROBBINS, L. G. SCHNEIDER, G. H. SHEA. Paper No. 121B. Paper introduces "CRC Diesel Engine Rating Manual," prepared by Group on Full Scale Test Techniques of Diesel Vehicle Fuel, Lubricant, and Equipment Research Committee of Coordinating Research Council; manual, intended to furnish universal language for identification of engine deposits and wear, is divided into general considerations and detailed rating techniques; use of manual.

New ¼ Ton Military Utility Tactical Truck, A. A. PARQUETTE, R. E. KRAEMER. Paper No. 125A. Development of M151 vehicle by Ford Motor Co.; basic design objectives and load assumptions; vehicle will carry driver and three passengers, or 800 lb of cargo cross country, or 1200 lb on highway and operates under all weather conditions; body and frame are of integral, all steel, spot welded construction; vehicle has 4-cyl, in-line, liquid cooled gasoline engine; description of each component, methods used in design analysis, and tests to which components were subjected.

Radioactive Cylinders — Tool for Wear Research, W. C. ARNOLD, V. T. STONEHOCKER, W. J. BRAUN, D. N. SUNDERMAN. Paper No. 126A. Program undertaken by Fairbanks, Morse and Co., Beloit, Wis., in conjunction with Batelle Memorial Inst., Columbus, Ohio to study feasibility of irradiating diesel cylinder; development of irradiation techniques and procedures devised; mechanical, handling and installation techniques; radioassay techniques which permitted precise analysis of fractions of wear product debris collected from lubricating oil and exhaust gas systems.

Fuel and Ignition Systems of Free-Piston Refrigerant Compressor, J. H. McNINCH, D. G. MARK, R. J. McCRORY. Paper No. 126B. Paper describes upper, or engine, end of free-piston compressor, developed at Batelle Memorial Inst. for use in residential air conditioning system; severe design requirements imposed on fuel-injection and ignition systems; principle and sequence of operation of direct gas injection system; details of specially developed proximity ignition system, in which spark timing is determined by piston position.

Numerical Control in Body Engineering — Fact and Fantasy, J. C. GORHAM, J. R. BALLINGER. Paper No. 129A. Review of manufacturing concept developed known as Numerical Control; development of electronic control units and techniques of data processing; four elements of numerical control are data processing, electronic control unit, serve loop system, and machine tool; interrelationships which must be considered.

Simplified and More Versatile Fuel Injection Pump to Meet New Applications, E. J. WILLSON, V. D. ROOSA, T. HESS. Paper No. 130A. Problems encountered in developing Roosa Master Model "DB" pump, devised by Hartford Machine Screw Co., Hartford, Conn., to meet demands of diesel

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engine field; main design objectives were standardization and single housing configuration that could be mounted either horizontally or vertically; basic design features: inlet metering, transfer pump regulation means, governor operation, and self lubrication; other features.

Seal Testing to Establish Quality Control Specifications Can Reduce 'Leakers', R. L. DEGA, J. D. SYMONS. Paper No. 130B. Program undertaken by General Motors Research Laboratories to Investigate causes for seal leakage and to determine basic design criteria; major parameters of seal application which affect its efficiency and life as determined by controlled laboratory testing are shaft, surface roughness, machining lead, assembly, and seal; most important parameters are seal diameter control, lip pressure, and eccentricity; tests and air gage developed called "Sealector".

Horsepower Rating for Commercial Vehicle Brakes, J. H. KING, A. F. STAMM. Paper No. 131A. Pt A outlines objectives of AMA-TTMA Committee's efforts to rate hp absorption capacity of commercial vehicle brakes, and progress made to date. Pt B analyzes energy relations involved in stopping of vehicle as compared to holding steady speed down given grade with due regard to transient and steady state braking conditions; functions involved are expressed in equations.

Transistor Switched Ignition Systems, G. E. SPAULDING, Jr. Paper No. 132A. Limitations of present systems as to ability to fire fouled spark plugs and developed sufficient voltage for higher compression ratio, higher speed engines; approach taken by Electric Autolite Co., Toledo, Ohio, in employing power transistors to switch increased currents imposed by increased ignition demands; use of "slow coil" to adapt germanium transistor to h-v ignition system; transistorized ignition circuit; immediate and expected applications.

Basic Principles of Ground Cushion Devices, G. D. BOEHLER. Paper No. 133A. Analysis of operation of ground-effect machines (GEM); defined as devices which operate in close proximity to earth's surface separated by cushion or layer of air; propulsion and control must be of aerodynamic nature; main categories of GEM"s established are ram wing, peripheral

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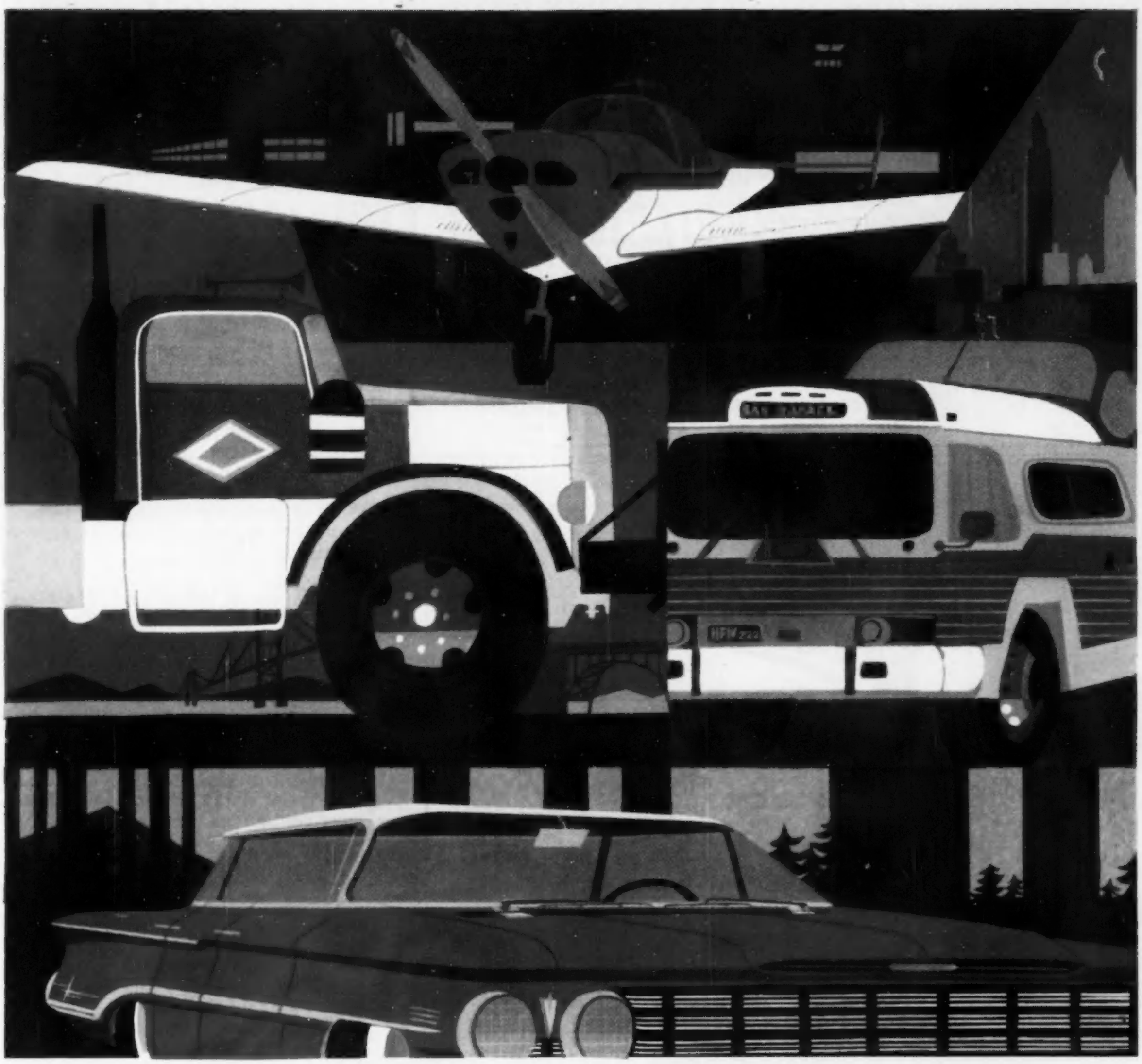

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seal, such as non-recirculating annular jet, recirculating labyrinth seal, diffuser, peripheral air leakage, such as plenum chamber, and levapad; basic principles involved. 70 refs.

Sliding on Air, A. L. HAYNES, D. J. JAY. Paper No. 133B. Principle of Levacar, developed by Ford Eng Research, which is essentially guided "airplane" that flies without benefit of wings: it can use propulsion systems such as ducted fans, propellers, or jet engines; paper centers around levapads which are frequently classed with air lubricated bearings because air is used as lubricant; how levapads differ from air bearings is shown by various calculations with respect to load-carrying capacity and pressure distribution and study of levapad vibrations.

Case for Ocean-Going Ground Effect Machine, H. R. CHAPLIN. Paper No. 133D. Summary of practical performance picture of true ground effect machine (GEM), under development at David W. Taylor Model Basin of U. S. Navy Dept.; analysis of hovering and cruise performance, stability, and operation over water; problems associated with latter; it is concluded that over large bodies of water, it might be possible to operate at heights of order of 10 ft.

Placing Maintenance in High Priority Category, G. R. CUTLER, E. B. OGDEN. Paper No. 135A. Approach taken by Transcontinental Operations, Chicago, Ill., in operation of freight liner trucks; establishment of equipment and methods development department devoted to program of controlling maintenance procedures and proper tooling, and design of future equipment with respect to correction of old problems.

Strong Management — Better Maintenance, H. L. WILLETT, Jr. Paper No. 135B. Organization from viewpoint of National Truck Leasing System is defined in terms of functional type organization structure, and product type, geographic separation, and line vs. staff, and decentralization types of structure; company objectives and their relation to company organization structure.

Management, Men and Machines, M. K. SIMKINS. Paper No. 135C. Examination of three areas — management, men and machines, used either directly or indirectly in truck transportation with respect to maintenance departments and operating costs; responsibilities and function of fleet superintendent; controlled test program whereby new products can be field-tested under normal fleet operating conditions is recommended.

Chrysler Corporation Unit Construction Story, J. W. SHANK, R. H. KUSHLER. Paper No. 137A. Story of development of "Unibody" unit; experimental phase, or development progress prior to decision to use unit construction, and product design phase, or final development; alternate approaches considered; styling and comfort requirements; manufacturing considerations and understructure assembly sequence; front and rear structure, and center pillar development; laboratory and road testing; corrosion protection and sound reduction.

Reduction of Air Pollution by Control of Emission from Automotive Crankcases, P. A. BENNETT, M. W. JACKSON, C. K. MURPHY, R. A. RANDALL. Paper No. 142A. During tests, carried out at General Motors, it was found that gases heretofore considered not significant, are important source of air pollutants; data on composition of blowby gases; evaluation of crankcase and exhaust gas hydrocarbon emissions using analytical techniques, and method of eliminating these gases by internal ventilation of crankcase to engine intake.

Application of Multiple Shoe Brakes,

(continued on p. 137)

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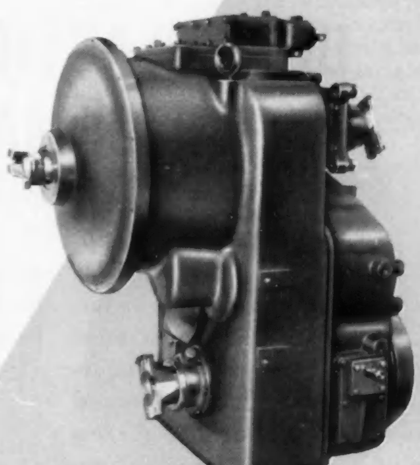

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In addition, backing formulations made with Latex 2582 are highly resistant to stains – even copper and other metallic dyes—as well as to fading and aging. Dow supplies Latex 2582 both to backing formulators and to fabric manufacturers.

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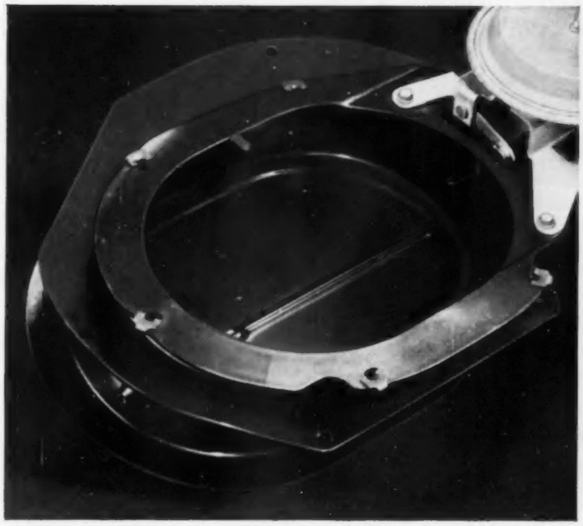

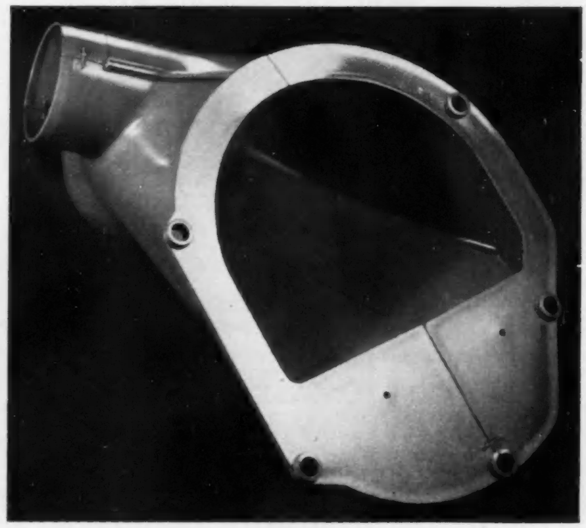

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Briefs of SAE PAPERS

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P. F. BLACK. Paper No. S-211. The design and operation of multiple shoe brakes is reviewed. These brakes have been applied to a wide variety of vehicles, ranging from wheel chairs and light training airplanes to the largest jet transports, 200-ton amphibious barges, and heavy earthmoving equipment.

Rotating Combustion Engine, ROY T. HURLEY. Paper No. S-236. Description, operation, and possible uses of CW Rotary Combustion Engine are given, along with test results, including graphs.

Automotive Differentials, N. R. BROWNYER and L. G. BOUGHER. Paper No. S-242. Various types of differentials are described, including both conventional and limited-slip or torque-responsive ones. The latter type, with torque bias added by friction, are currently in greatest favor for improving traction in passenger cars and other light vehicles. The authors point out that these devices give only an approximation to desired results.

FUELS & LUBRICANTS

Two-Cycle Engine Lubrication, D. C. BARDY. Paper No. S-232. Lubrication problems associated with 2-stroke engines are listed, and the effect of blending additives with motor oils for 2-stroke engines is outlined. Results of 35-hp outboard motor tests with several additives are also included.

NUCLEAR ENERGY

Direct Conversion of Heat to Electricity: Thermionic Method, R. W. PIDD. Paper No. 120A. Technological position of reactor power plant and review of processes used to convert atomic heat into electricity; thermocouple as power producer; development of cesium converter which can be readily adapted to reactor design; method of direct conversion whereby electric power is produced directly at fuel surface and extracted from reactor core; proposed temperature of 2000 C appears feasible on basis of laboratory data.

Large Direct Conversion Space Power Systems, T. F. NAGEY, R. E. HENDERSON. Paper No. 120B. Review of nuclear electrical power systems and research required for direct conversion; comparisons to solar conversion systems; characteristics of LiH thermally regenerative fuel cell, doped FbTe thermoelectric convertor, and close spaced thermionic diode which are used as examples of direct conversion devices; development of solar direct conversion systems in 1 mw class competitive with nuclear systems is believed to be possible.

Thermionic Direct Conversion Studies with Noble Gas Plasma Diode, F. E. JAMERSON. Paper No. 120C. Program conducted at University of Michigan on direct conversion of nuclear fission heat to electricity in plasma diode; fission fragments from uranium bearing cathode are used to produce plasma of relatively low fractional ionization in noble gas; experiment was performed in University's research reactor in which uranium carbide cathode was operated up to temperatures of 2000 K; experimental data and measured diode characteristics.

Radioactivity — Guide and Energy for Future Automotive Safety, J. J. GREBE, D. E. HARMER. Paper No. 123A. Suggestions made to improve production, fueling, and safety guiding of automobiles; radioisotopes for determining tool and part wear of engines; neutron-activation analysis and catalytic effects of radiation itself on chemical systems and plastics; one field offering potentials is that per-

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How Aluminum Bumpers

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cut weight,
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versatility

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AiResearch Industrial Division

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DESIGNERS AND MANUFACTURERS OF TURBOCHARGERS AND SPECIALIZED INDUSTRIAL PRODUCTS

Briefs of SAE PAPERS

(continued from p. 137)

taining to safety of vehicle operation; detection systems for vehicle with respect to roadway, infrared radiation emitters to transmit change in speed of vehicle ahead, etc.

Propulsion Sub-System Areas Requiring Definition and Development in Preparation for Operational Nuclear Rockets, R. B. CLAPPER, A. CORBIN. Paper No. 123B. Major sub-systems are propellant and necessary tankage; turbopump to feed supply propellant; reactor to heat propellant; thrust chamber and nozzle to convert heat energy to kinetic energy; control system and shielding to protect sensitive components; rocket system developmen philosophy and establishment of performance and development goals; optimization and control sequence; suggested time schedule for each of sub-systems.

MATERIALS

High Temperature Materials and Their Heat Treatment for Anti-Friction Applications, O. W. McMULLAN. Paper No. 122A. Paper deals with steel and its heat treatment employed in antifriction bearings for gas turbine engines; available materials are classified into those suitable up to various temperature limits ranging from 450 to above 1500 F; metallurgical problems in heat treatment of high alloy content steels; retainer materials; major constituents of three most commonly used cage materials are listed.

New Plastic Bearing Materials—Greaseless Car in Your Future, R. E. HARMON. Paper No. 122B. Plastics considered as dry bearing components such as TEFLON TFE fluorocarbon resin, nylon, FEP fluorocarbon and acetal resins, latter two being in development production stage; classification of dry types and evaluation of applications for natural state plastic, filled plastic mixtures, impregnated wire screen and perforated metal, woven fabric, and impregnated porous bronze with metal backing bearings: factors affecting service life.

Influence of Variations in Surface Properties of Steel on Corrosion Resistance of Body Panels, G. L. LEITHAUSER. Paper No. 134A. Objectives of program of steel and automotive manufacturers, established to determine cause of corrosion differences noted in tests made in 1954 and repeated in 1959; tabulated results of samples from 19 different heats; results of primer systems tested showed that most effective system consisted of acrylic-type flash primer applied to phosphated steel prior to primer surfacer with no intermediate baking; further study required.

Development of Corrosion Control on American Motors Corporation Single Unit Construction Body, J. L. MOLNAR, W. SNYDER. Paper No. 134B. Approach applied to overcome corrosion problem particularly evident in areas of country using de-icing chemicals on streets and roads; it was found that corrosion was well advanced on uncoated inside surfaces of lower box sections; program undertaken to coat these surfaces with deep dip primer, reinforced with application of inhibited wax in most critical areas; preparation of body for deep dip primer.

Chrysler Corporation's New Corrosion Protection Process, C. P. DURBIN. Paper No. 134C. Study of corrosion protection treatments to interior surfaces of body structural members; areas requiring protection; supplementary protection given to areas not coated with immersion primer or which are expected to be subjected to extremely severe corrosive environments; steps employed in process.

COMPUTERS

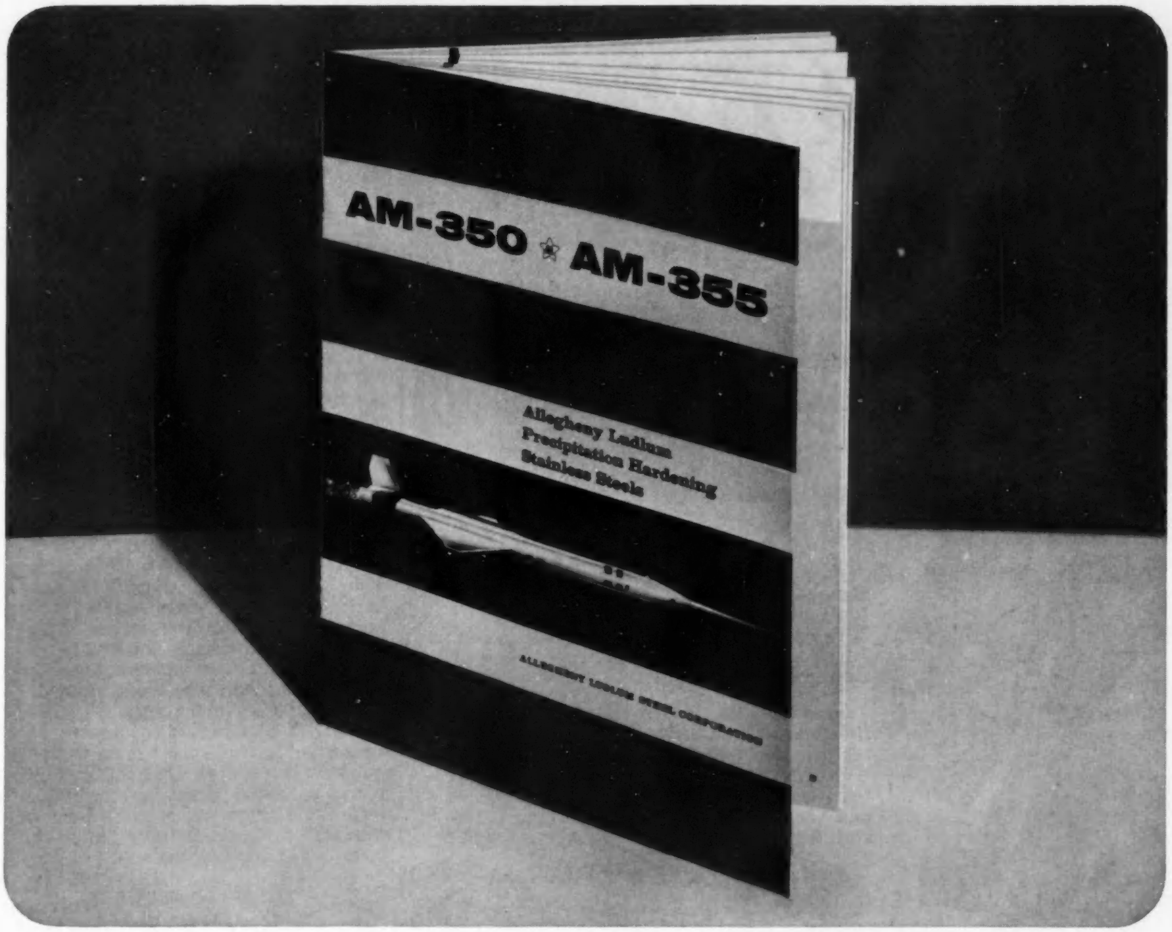
Computer Solves Complex Suspension Geometry Problems, K. L. HOYT, C. F. MADDOX, N. R. MILLER, D. F. ZAWADA. Paper No. 127A. Program at Ford Motor Co. for solution of double-wishbone front suspension for 1-f spring medium is also applicable to either front or rear suspensions and variations in type of spring; necessary data are: paths in 3 dimensions of upper and lower ball joints; wheel center path, path of tire to ground contact point with wheel rolling and braked, path of lower attachment for springing medium, spindle steering arm ball joint path, camber and caster change in degrees.

Computer Technique for Designing Engine Mounts to Control Shake, E. STEPP. Paper No. 127B. Response of engine mounting system for given force and frequency is combined response of several modes which cannot be separated and identified easily by experimental methods; steps in designing system to control shake; computer technique, applied by Chrysler Corp., shows how one engine mode can be tailored to control bending mode of shake; same process can be used to match more than one mode to structure; idle performance and noise transmission characteristics indicated.

Computer Analysis of Automotive Drivetrains, S. E. STAFFELD. Paper No. 127C. Digital computer is employed by Chrysler Corp. to solve two types of vibration phenomena: unbalance in propshaft which excites vibra-

(continued on p. 144)

Experience—*the added alloy in* **Allegheny Stainless**



New booklet on A-L's precipitation-hardening stainless steels, AM-350 and AM-355

A tool for anyone interested in high strength-to-weight metals

In this technical booklet, you get the facts on Allegheny Ludlum's precipitation hardening stainless steels, AM-350 and AM-355, metals developed for space age requirements.

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858

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A-L

Briefs of SAE PAPERS

(continued from p. 142)

tion at first order frequency, i.e., one cycle of vibration for each revolution of shaft; universal joints which generate second order forces and moments, magnitudes of which are proportional to joint angularity; general statement and computation; computer sequence; its application makes it possible to deal with increasing large number of combinations of power plants, transmissions extensions and propshafts.

DYANA Computing System and Its Applications, J. T. OLSZTYN, B. HARGRAVES, T. J. THEODOROFF, E. L. JACKS. Paper No. 127D. System for IBM 704 computer and its components; DYANA program consisting of description of vibrating system investigated, mathematical expressions required, and set of statements; compiler prepares mathematical model, numerical procedures, and organizes these into FORTRAN program; system, designed for study of spring mass damper systems, is capable of handling dynamic problems whose mathematical models are represented by systems of ordinary differential equations; two examples of applications.

MISCELLANEOUS

How to Write Effective Technical Reports, T. C. HICKS. Paper No. 124A. Importance of technical reports as tools in industrial decision making is shown; paper shows engineers and scientists how to prepare better reports, and how to make them more accurate, timely, and effective.

Literature Engineering on The Why and How of Engineer in Library, R. E. RUNSER. Paper No. 124B. Role of library in general, specialized technical and research library for engineers; librarian's functions; use of library card catalog, indexes and abstracts, bibliographies, subject handbooks and manuals.

Guide to Automotive Engineering Literature, E. B. JACKSON, E. V. WRIGHT, R. MacDONALD. Paper No. 124C. Literature essential to automotive engineer concerned with chassis, power plant, and power train of vehicle is presented; bibliography, offered as "Automobile Engineers Five-Foot Shelf" contains compilation of abstracts and indexes; comprehensive bibliographies; bibliographic references in periodicals; bibliographic services; dictionaries; handbooks; special reference works; books, pamphlets, etc. and periodicals.

New Members Qualified

These applicants qualified for admission to the Society between March 10, 1960 and April 10, 1960. Grades of membership are: (M) Member; (A) Associate; (J) Junior.

Atlanta Section: Cato Wilson (M).

British Columbia Section: W. H. Craig (A), Elijah Enefer (A), John H. Friswold (M), William Clarence Jones (A), David Murray Stewart (A), James Victor Whitehead (A).

Buffalo Section: Duane R. Crumb (M).

Central Illinois Section: Donald C. Dowdall (J), Stephen F. Glassey (J), Harold Joe Harp (J), Kenneth Wm. Mettelmann (J), Dean E. Miller (J).

Chicago Section: Robert W. Andersen (J), Roy J. Anderson (A), George A. Berry III (A), James J. Berta (A), James F. Bice (J), Marvin L. Brown (J), James R. Colvert (M), William A. Cooper (M), Arthur W. Donkin (M), Wilton E. Quant (M), Duane L. Repp (J), Roger A. Rice (J), Kenneth R. Robinson (J), James F. Sauer (M), Ronald A. Steen (J), Ted Tom (M), Leon A. Wirt (J).

Cincinnati Section: Richard L. Eubanks (A).

Cleveland Section: Joseph P. Balionis (M), Daniel T. Hanlon (M), John Joseph McFadden (M), Louis S. Papp (M), Walter H. Schefft (M), Rudolf Hans Schleicher (J).

Dayton Section: Tali A. Abul (J), John L. Lenz (M).

Detroit Section: Van E. Aldrich (A), William P. Bamford (M), Roland James Barlow (M), Philipp Becker (J), Roy W. Best (M), James L. Byrne (J), Glenn L. Calcamuggio (M), Louis E. Calvin (J), Harry G. Chassie (M), Michael Robert Dragon (M), George R. Fead (A), Laurence G. Feiler, Jr. (A), Jerome John Frankowski (J), Richard Gulau (J), Otto Habrecht (M), James F. Hoffman (M), George A. Kostka (M), Richard J. Kotch (A), Gerald T. Kozlow (M), Harold A. Maloney (M), Odell C. Mercer (M), David Franklin Merrion (J), Richard E. Muller (J), Hunter L. Oden (J), Leonard J. Paciorek (J), Raymond L. Porter (M), Jerry Anthony Pretti-Pavletta (M), Erwin G. Rapske (A), Lloyd E. A. Reuss (J), Russel O. Rice (M), Ralph Gordon Richardson (M), Richard George Rupli (J), William C. Sink (M), David A. Sloss, Jr. (J), Robert G. Stanwood (A), Richard Swiatek (J), Ernest Toth (A), Charles W. Unbehaun, Jr. (M), Lawrence Marvin Weathers (J).

Hawaii Section: Eric Holloway (A).

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New Members Qualified

(continued from p. 146)

Indiana Section: Robert J. Hays, (A), Julius P. Perr (J).

Kansas City Section: Robert A. Hanson (A).

Metropolitan Section: Joseph A. Bryant (M), Richard A. Franchi (J), Robert W. Legge (M), John B. Littlefield (M), Edward R. Mueller (M), Carl John Rebhahn (M), James P. Santos (J), Gilbert W. Speed (J).

Mid-Continent Section: Robert L. Carder (M), M. Duane Lackey (M), M. Gene Whitehead (A).

Mid-Michigan Section: Earl W. Glover (A).

Milwaukee Section: Hubert John Anderson (M), Richard T. Brandt (J), Gilbert C. Hahn (A), Jerome O. Just (J), Robert Charles Shebuski (J), Wilmer E. Witt (M), Neill C. Woelffer (J).

Montreal Section: Alfred John Japp (M).

New England Section: F. Richard Ellenberger (M), Robert G. Griffing (A), Eugene W. McCarthy (A).

Northern California Section: Glen William Bickley (A), Leo S. Takeuchi (J).

Northwest Section: Clifford L. Atwood (A), Alfred F. Benz (M), Andrew J. Erickson (A), I. Grant Fowler (A).

Ontario Section: Frank William Baker (A), Gordon Kenneth Pickering (A), Walter J. Washburn (M), David H. Williamson (A).

Philadelphia Section: Francois Ernest Didot (J), Hans Peter Gull (M), Frank W. Klinger (M), W. W. Tilden (J).

St. Louis Section: James H. Detenbeck (M), Wilkes L. Maddox (M).

Salt Lake Group: Thomas L. Gray (M), Donald D. Kriens (M).

San Diego Section: Stanley E. G. Hillman (A).

Southern California Section: Gene Charles Bessolo (J), Ernest Theodore Hillberg (M), John Nye Morgan (M), Henry A. Smolinski (J), Jack P. Wright (M).

Southern New England Section: R. W. Vose (M).

Spokane-Intermountain Section: F. W. Fischer (A).

Texas Gulf Coast Section: Arthur Ray Dudley, Jr. (M).

Twin City Section: Robert Penfield Borden (M), Roland Haller (J), James McCormick (M).

Washington Section: Robert Glenn Alexander (M), Edward Paul Wizniak (J).

Western Michigan Section: Lewis M. Davis (M), Richard E. Murbarger (A).

Williamsport Group: Thomas D. Cooney (M).

Outside Section Territory: Douglas C. Ager (J), Jerome J. Bush (J).

Foreign: Paul G. Axelrad (M), Brasil; Paul Berliet (M), France; Prija Chongvatana (J), Thailand; Francisco J. Gutierrez S. (M), Mexico; Charle Edward MacLennan (M), France; K. Viswanathan (J), So. India.

Applications Received

The applications for membership received between March 10, 1960 and April 10, 1960 are listed below.

British Columbia Section: C. J. Makin, Douglas Stanyer

Buffalo Section: Norman G. Bruinsma,

(continued on p. 152)


25
OOL
CAPACITY
48 SCHOOL CHILDREN
NO STANDEES

Budd wheels deliver... everything

In every part of the country, every corner of the world . . . Budd-made wheels are used for the transportation of all kinds of cargo . . . from school children to ballistic missiles. More than 60 million wheels for trucks, trailers, buses and off-the-highway vehicles have rolled from Budd plants. And many of them are still rolling after more than 5 million miles.

A recent Budd development has now produced wheels that are 10% stronger . . . with no addition in weight, no increase in cost. Such developments are typical of the foresight with which Budd facilities are being applied to serve the automotive industry. The Budd Company, Detroit 15.

AUTOMOTIVE Budd DIVISION

Since 1916 — serving the automotive industry with research, design, engineering and specialized production facilities.

Applications Received

(continued from p. 148)

Robert E. Dutcher, Russell S. Genco, Marlyn Duane Tanis

Central Illinois Section: Donald E. Berge, William P. Edwards, Emidio L. Gaspari, Donald Allen Holtkamp, Donald E. Merritt, Clyde B. Norman, Frank H. Riddle, David L. Taylor

Chicago Section: Ralph C. Archer, Andrew Blaauw, Walter Fisher, Edward Carl Grahn, Norman Russell Hinkle, Elbert A. Hoffman, Lee Carlton Hoppe, Roger L. Hulslander, Earling C. Johnson, Charles M. McClure, Joseph A. Nava, Brian Keith Neil, Edward C. Oldfield, Gunther Pfeifer, Frank M. Poskozim, Gus L. Poulos, Gerald E. Ritchey, Jerome Conrad Rosenwald, Robert W. Vierck, Baldev Singh Virdi

Cincinnati Section: Arnold M. Leas, Robert H. Wettach, Jr., James Cody Williams, Edward P. Zelnis

Cleveland Section: E. D. Abraham, Alan C. Birchler, Robert C. Brooker, Kenneth L. Campbell, Jr., Richard Harry Fleming, John W. Henry, M. C. Hoffman, Richard A. Janssen, Robert Moran, Donald W. Prideaux

Colorado Group: Kurt F. Kircher

Dayton Section: Theodore L. Bayless, Walter J. Braun, Roger L. Frantz, John A. Losh, William E. Metzger, Yoshitaka Yoshida

Detroit Section: Philip G. Arndt, Bruce H. Bacon, Robert O. Bowersox, W. B. Calhoun, Jr., William C. Cameron, Russel Gilbert Corbin, Archibald C. Doty, Jr., Charles P. Fowler, Jakob K. Jakobsen, Gerald H. Kass, Addison B. Kelley, Lawrence R. Kirby, James Edward Luxenberger, Robert E. Manion, Samuel A. Mazzola, Jr., Bingham Andrews McClellan, Ralph McClintock, Samuel D. McCready, Donald McKenzie, Thomas F. Moormann, Donald Thomas Mullaney, George Richard Muster, Miguel Parets, Albert W. Post, Samuel B. Robbins, Walter C. Root, Bela Sandor, W. J. Scarborough, Iain McMaster Scott, John L. Seeley, Edwin J. Seiberlich, Charles Henry Torner, Harry C. Van Matre, James A. Winnale

Fort Wayne Section: Stuart S. Bower, Bill J. Martin, Robert Eldon Mee, Paul Everett Merriman, Allan Vegell, H. Franklin Wright, Jr.

Hawaii Section: Jack A. Edwards, Richard C. Locey, Wallace C. S. Young

Indiana Section: Charles Joseph Almond, Ronald J. Deal, Frank R. Hubler, Ralph J. McDaniel, Phillip J. Ritchie, Robert L. Sharpe

Metropolitan Section: Joel Raymond Bumpus, Daniel T. Cahill, Earl J. Cook, Michael E. Errico, Ivan O. Fieldgate, Frank Jannelli, Jr., Carl Orsini, Donald L. Pasquine, Richard A. Sigerist, Harrison Shaw, Paul Szulborski, Robert William Thomson

Mid-Continent Section: Gary A. Bagby, Ronald Lee Miller

Mid-Michigan Section: Philip E. Smith, John A. Zidak, Jr.

Milwaukee Section: Barrett N. Alexander, Joseph L. Johnston, Gordon J. Lis, Lawrence Thomas O'Donnell, Joseph R. Wright

Montreal Section: Norman Walter Kuster, Jean Guy Lecuyer, Gordon Walter Little, Pawuin Marius

New England Section: Paul J. Barnico, Werner G. Holzbock

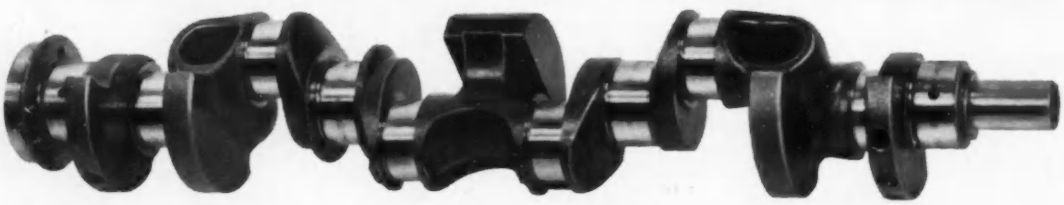
Northern California Section: Donald Lee Beers, Ralph B. Blodget, Vernell Matson Hance, E. C. Schaber

Northwest Section: Carlisle King, Donald E. Olson

Ontario Section: Brian Gregory Barden, Lewis Lees Buckley, Harold G. Deline, Michael A. Haddon, Neville John Edgar Hartwell

(continued on p. 155)

FORD'S FALCON CRANKSHAFT...



SHELL MOLDED EFFICIENTLY WITH

RCI FOUNDREZ RESIN!

Ford is mass-producing Falcon crankshafts by the shell mold process — a method as modern as the compact car itself.

And an RCI phenol-formaldehyde FOUNDREZ resin is used extensively to produce the shell molds for this important Falcon casting.

This combination of process and resin provides an economy born of efficiency. Here's why!

The shell mold process offers specific advantages:

- pattern dimensions can be reproduced more exactly
- castings have closer tolerance, require less machining
- shell molds are portable and use less sand
- in fact, foundry efficiency, flexibility and production rate are increased

And RCI FOUNDREZ resins are ideal for shell mold applications because:

- RCI is a basic producer of both phenol and formaldehyde, which guarantees quality control from raw material to finished product.
- RCI's experience, gained during 35 years of diversified synthetic resin manufacture, assures expert technical service.

The advantages of shell molding may apply on one of your foundry jobs. Write to RCI Foundry Division for detailed information on FOUNDREZ resins.

Creative Chemistry ... Your Partner in Progress

REICHHOLD FOUNDRY PRODUCTS

FOUNDREZ — *Synthetic Resin Binders*
COROVIT — *Self-Curing Binders*
coRCIment — *Core Oils*
CO-RELEES — *Sand Conditioning Agent*
REICOTE — *Sand Coating Agent*

REICHHOLD CHEMICALS, INC., RCI BUILDING, WHITE PLAINS, N.Y.

Applications Received

(continued from p. 152)

Oregon Section: William A. Prothero

Philadelphia Section: James David Conboy, Leonard J. Grecco, W. Haddon Judson, James M. Lewis, William Merriel Shook, Sr., John H. Warren

Pittsburgh Section: David Michael Capone, Larry Duffield Duquette, Lucian J. Leta

Rockford-Beloit Section: Paul F. Marshall

St. Louis Section: Edgar Ralph Schneider

Salt Lake Group: Gerald Leon Coakley, William Clyde Neal, William S. Watson

San Diego Section: Reinhold L. Gerber, Billy Don Sevier

Southern California Section: Horace L. Beaty, James Bernard Farrow, Jr., Alfred Herman Greiert, Jr., C. J. Howard, Percy W. Mestman, Stanley Chester Neff, Branson Moore Payne, Arthur G. St. Onge, Theodore G. Thometz, Jerome Warner Thompson, Donald M. Veihman, Tibor Wiener

Southern New England Section: Theodore M. Adgate, William T. Blake, James A. Cronin, Carman Alfred Ritchie, C. William Steele, Jr.

Syracuse Section: Maurice William Burgher

Texas Section: Wilson Hoag, Jr.

Texas Gulf Coast Section: Ivy B. Langford

Twin City Section: Calvin H. Schwalbe, Donald C. Staab

Washington Section: William J. Neff, Norman H. Petersen, Daniel T. Pickett, N. E. Promisel

Wichita Section: John Francis Melaugh, Jr.

Williamsport Group: Richard W. Fullerton

Outside Section Territory: Tommy D. Badley, Douglas Elton Brotherton, Charles W. Davis, Arthur S. Gloster, II, John Richard McCorkle, Robert J. Wicke, Joseph W. Wiswall

Foreign: Suresh Kumar Agarwal, India; John Owen Dewan, West Australia; Richard Henry Holland, Western Australia; Robert Jones, East Africa; Aurele P. MaMere, Turkey; John Allen Pankhurst, New Zealand; Josephus van Rosevelt, Holland

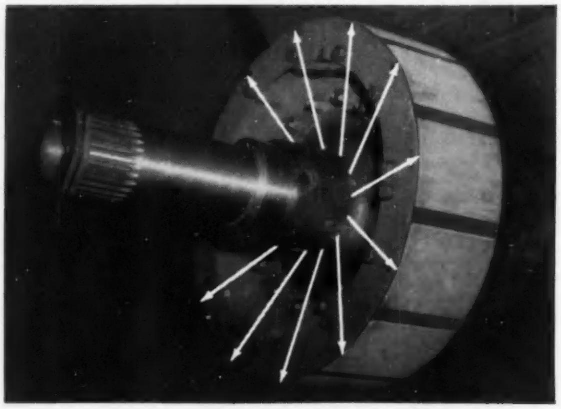
New tractor with Hi-Torque brakes stops 200,000-pound load short

Clark Equipment Company chose B.F.Goodrich Hi-Torque brakes when they designed their ACT-225 model jet towing tractor—and for a good reason. BFG Hi-Torque brakes provide the extra braking capacity needed for handling today's big jets.

This Delta Air Lines DC-8, for example, weighs approximately 120,000 pounds empty, 300,000 pounds fully loaded. And it costs over 5 million dollars—a big investment to protect during swift ground handling operations. The Hi-Torque brakes, on all four wheels, provide full circle contact with the drums, for a total of 720 square inches of braking surface. Result—up to double the braking power of conventional brakes.

On all types of heavy-duty vehicles, Hi-Torque brakes give added capacity for shorter, safer stops. Investigate Hi-Torque brakes for your equipment: available in sizes from 17¼" x 4" to 26" x 7". Brakes can be operated by either air-over-hydraulic or direct-hydraulic actuation. Call or write *B.F.Goodrich Aviation Products, a division of The B. F. Goodrich Company, Department SJ-5, Troy, Ohio.*

Full circle contact with drum is provided by Hi-Torque brake. Increased effective braking surface with uniform drum pressure stops vehicles twice as fast as conventional brakes.



B.F.Goodrich Hi-Torque brakes

The thicker the "Duplex Chromium"...

Corrodkote(1) and CASS(2) tests of M&T "Duplex Chromium" show that increased plate thickness enables bright trim to stay bright.

At last the automotive industry has the means to maintain the gleaming appearance of brightwork through years of exposure to moisture, slush, salt air and industrial atmospheres. Thicker chromium does it. M&T "Duplex Chromium," plated long enough to deposit sufficient thickness, can make all the difference . . . give the ultimate in results.

By every modern test, M&T "Duplex Chromium" has clearly demonstrated its superiority. CASS tests on steel and zinc die cast panels show that corrosion resistance is multiplied many times over. Corrodkote tests also confirm a 5 to 10 times increase in durability. Initial results of 2-year outdoor exposure of thicker chromium to Detroit atmospheres suggest the same pattern of protection.

You'll do more to prolong life of the bright finish by plating thicker "Duplex Chromium" than with any other change in plating specifications. A minimum chromium thickness of 50 millionths of an inch works a dramatic improvement. 100 millionths works wonders.

For plating thicker chromium, Unichrome SRHS® Chromium baths offer substantial operating advantages . . . such as higher speed, self regulation, and better coverage in recesses. More important, they offer the only way to get the right type of deposit. M&T "Duplex Chromium" combines two deposits from these baths. One layer is crack-free to block entry of corrosives to underlying metal; and to give better distribution of the plate so that recesses, too, get ample thickness with no grayness or burning at edges. The other layer has an extremely fine crack-pattern to avoid localized corrosion experienced at tiny surface defects in zinc die castings.

Existing production equipment of sufficient capacity can be used with minor modifications. Send for technical data; or for an M&T plating engineer to survey your plant requirements.

(1) Corrodkote test: a standard, uniform, highly corrosive slurry is applied on test piece, which is then placed in non-condensing humidity cabinet. Each cycle is 16 hours.

(2) CASS test: copper-accelerated acetic acid salt spray.

M&T plating products · welding products

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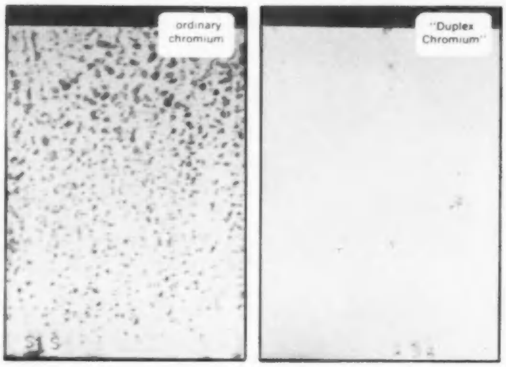
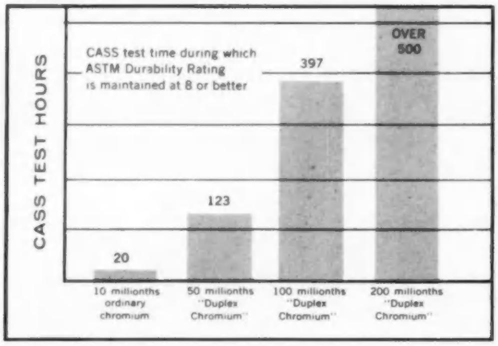
METAL & THERMIT CORPORATION, General Offices: Rahway, New Jersey

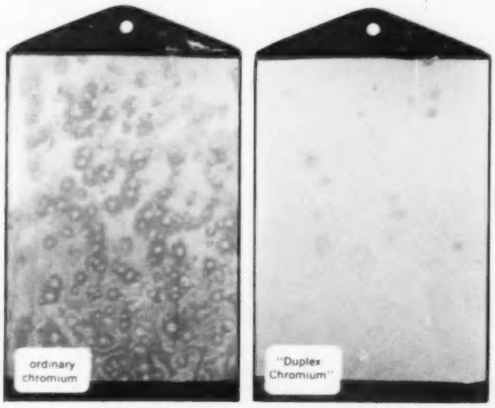
the longer the plating lasts!



The chromium plated steel panels above underwent 135 hours of CASS testing. Both had identical undercoats of 0.3 mil of copper and 1.0 mil of nickel. Yet one rusted, the other did not. Why? Because the left panel had only 10 millionths of an inch ordinary chromium plate . . . while right panel had 50 millionths M&T "Duplex Chromium."

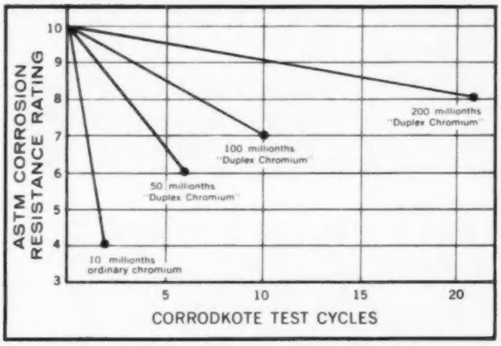
Graph below indicates how corrosion resistance increases with chromium plate thickness. The thicker the chromium, the more CASS test hours it can take.

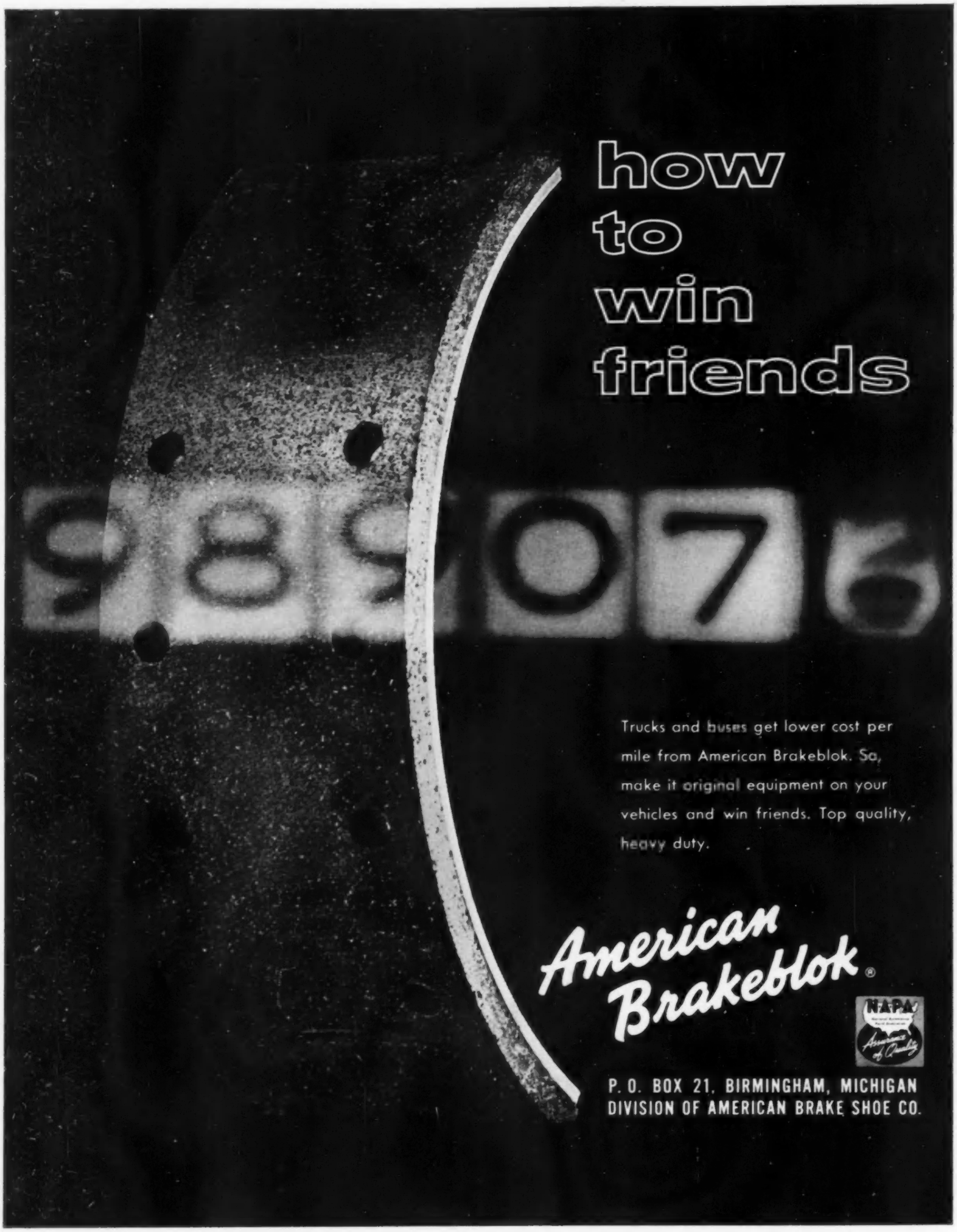


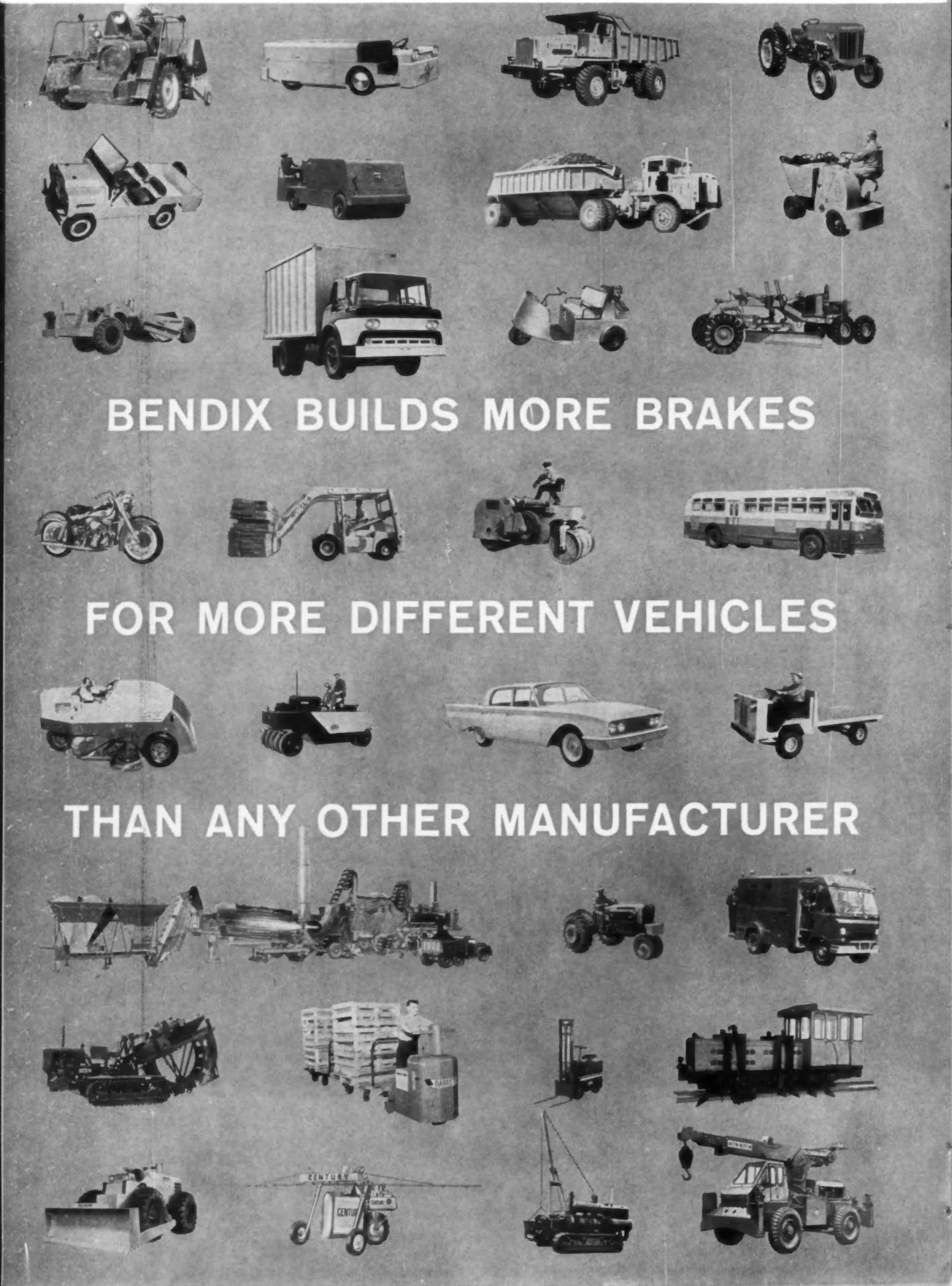


Same thing happens with zinc die cast panels in 4 cycles of Corrodkote testing. One corrodes badly compared to the other. Why? Same reason. Both panels had identical undercoats, but left one had only 10 millionths of an inch ordinary chromium, while the right one had 50 millionths of M&T "Duplex Chromium."

Graph below shows that in Corrodkote testing, too, the thicker the chromium, the longer will it keep its appearance near the perfect mark of 10 on the ASTM durability scale.

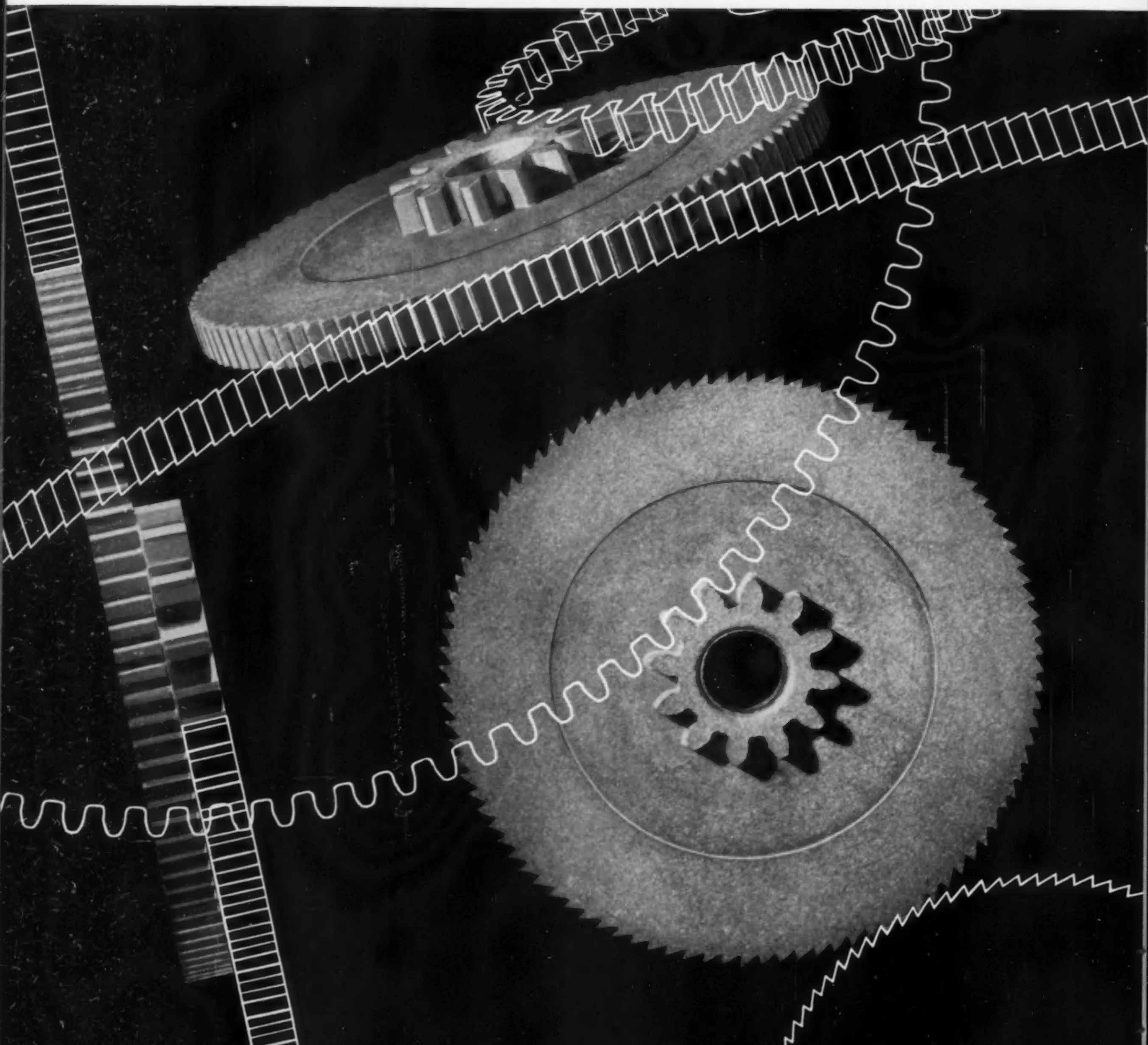



how
to
win
friends
989076
Trucks and buses get lower cost per mile from American Brakeblok. So, make it original equipment on your vehicles and win friends. Top quality, heavy duty.
American Brakeblok®
NAPA
P. O. BOX 21, BIRMINGHAM, MICHIGAN
DIVISION OF AMERICAN BRAKE SHOE CO.


BENDIX BUILDS MORE BRAKES
FOR MORE DIFFERENT VEHICLES
THAN ANY OTHER MANUFACTURER
CENTURY

REPUBLIC HIGH-PERFORMANCE PRODUCTS FOR DESIGNERS AND ENGINEERS

REPUBLIC HS6460 HIGH STRENGTH POWDER. This soft, alloy powder can be used to design and produce higher strength structural parts than ever before achieved with ferrous powders. And, at lower manufacturing costs than obtainable with copper infiltration. HS6460 is capable of a minimum tensile strength of 60,000 psi at 6.4 density as sintered—100,000 psi after heat treatment. Excellent carbon compatibility enhances its ability to be heat treated. Chemical composition, physical properties, and test evaluations on HS6460 are contained in Booklet ADV. 1028. Mail the coupon for your free copy.



NEW ONE-OF-A-KIND MICROGRAPH

draws pictures for bearing research

This greatly magnified stylus is drawing a picture of the microscopic imperfections in a bearing raceway . . . measuring each one to within a few millionths of an inch. The picture-on-tape which comes out of this specially modified micrological instrument is an important tool in BCA's research on ball bearing performance.

This is just one of the precision instruments in the Temperature-Humidity-Controlled Instrumentation Room which is the center of BCA research on bearings. The result of this program is revealed in on-the-job performance of BCA bearings. They roll dependably under heavy loads and all kinds of adverse conditions.

New testing facilities at the BCA laboratories also include specially designed equipment, often identical with equipment in customers' plants. Here, BCA bearings are tested to exceed customer specifications *under the exact operating conditions experienced by the customer!*

BCA ball bearings are standard original equipment . . . replacement, too . . . for nearly every kind of industry. For example, automotive, earth moving, agricultural and machine tools. The wide line of ball bearing sizes and types, plus BCA's research and extensive new testing facilities, pays off for bearing users. Consider the performance record of BCA ball bearings the next time you purchase or specify bearings. For more information, or for assistance with bearings problems, contact Bearings Company of America, Division of Federal-Mogul-Bower Bearings, Inc., Lancaster, Pa.

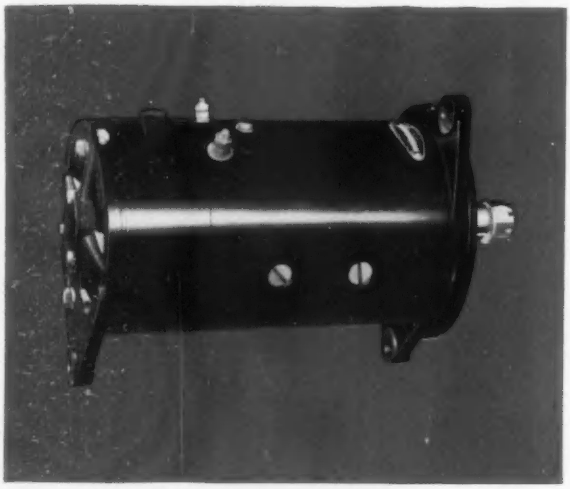
BCA

BEARINGS COMPANY OF AMERICA

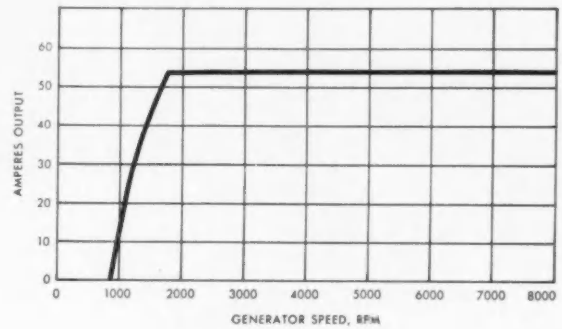
ball bearings

DIVISION OF FEDERAL-MOGUL-BOWER BEARINGS, INC.

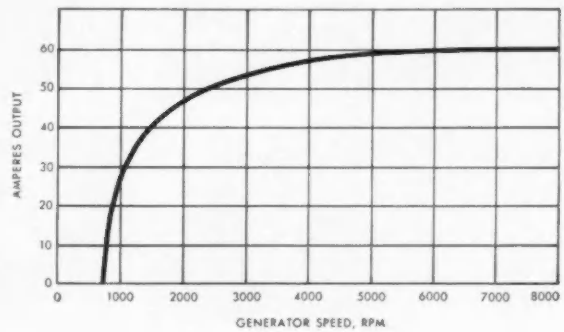
TAILOR YOUR TRUCKS

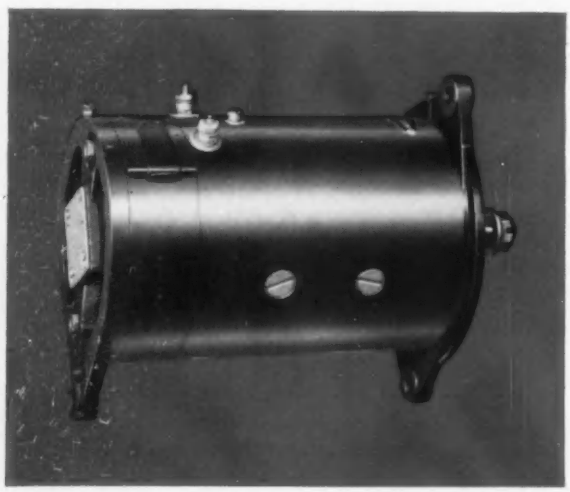


1106991 EXTRA-OUTPUT D.C. GENERATOR—12 volts • 55 amperes • 12 amperes at idle—For cross-country trucks, school buses and other vehicles with extra electrical equipment.

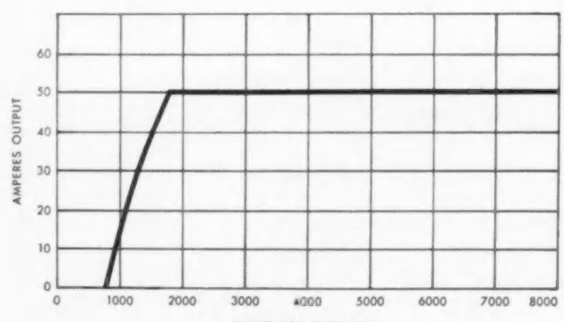


1117070 SELF-RECTIFYING A.C. GENERATOR—12 volts • 60 amperes • 27 amperes at idle—For high-duty vehicles with heavy electrical loads . . . operating at all speed ranges. Ideal for excessive low-speed operation and curb-idling.





1106985 EXTRA-OUTPUT D.C. GENERATOR—12 volts • 50 amperes • 14 amperes at idle—Short frame generator for difficult mounting applications. For vehicles in city and suburban use. Not for cross-country operation.



and a conventional system. The heat transfer coefficients in the valve and cylinder wall areas for the ebullient system were found to be two to three times higher than for the conventional cooling system!

Automotive cooling systems have always been a subject of intense study by Dow's automotive development staff. Dow is a basic producer of ethylene glycol coolants, and through the years Dow corrosion engineers screened many corrosion inhibitor combinations for one that could be used in all sections of the country. Since the main offenders in a cooling system are water impurities and their variants, it was decided to formulate a totally compounded fluid to eliminate the need to add water to the radiator. Thus, after a series of exhaustive performance tests, came DOWGARD*, the world's first year 'round cooling system fluid. A blend of a completely new combination of protective chemicals, and specially treated de-ionized water, DOWGARD gives superior protection to all cooling system metals — including aluminum!

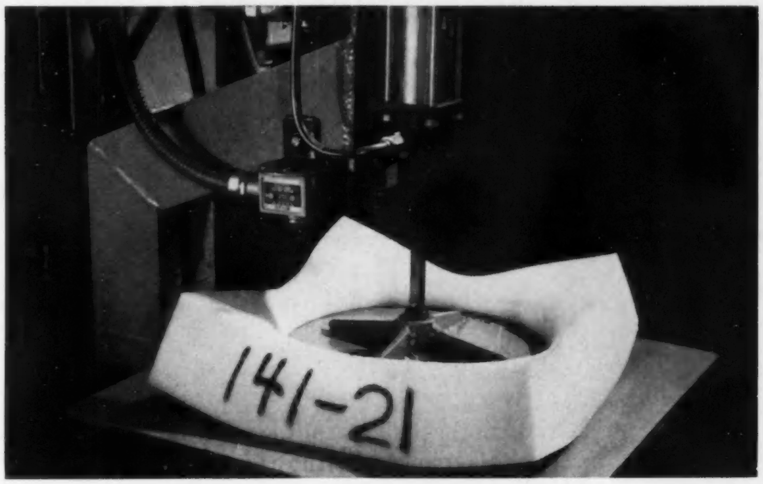
**Trademark*

NaOH: Workhorse in new flake form

The announcement that Dow has introduced a greatly improved new flake form of caustic soda . . . offering higher Na_2O content, and virtual dustlessness

New ground caustic flake is virtually dustless.

has been welcome news to the automotive industry. In many automotive plants, fast-acting formulations containing Dow caustic soda serve as metal cleaners, paint strippers, and waste disposal aids. Quick, dependable supplies of Dow caustic soda are available in all six forms: 50% and 73% solutions, as well as solid, flake, ¼-inch flake, ground flake.



Testing polyurethane foam for dynamic flexing.

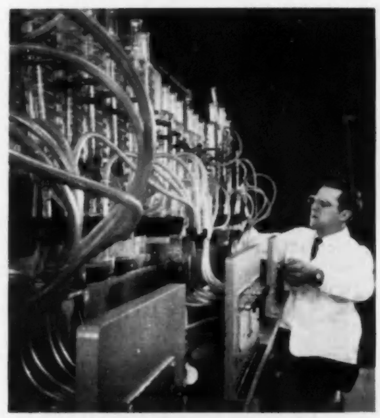
POLYGLYCOLS: from where you sit

In a driver's seat, resiliency, rigidity, and tensile strength are requirements for safe, comfortable driving. In the Dow Automotive Chemicals Laboratories, these are requirements for Voranol*, Dow resin-grade polyglycols used to make polyurethane foam seat cushions. Like the coolants, additives, and fluids that go under the hood, they were subjected to the same exhaustive research . . . are subject to the same high-purity requirements in Dow's automotive chemicals labs. And someday, you may see entire seat assemblies formed of this soft, yet tough material. Or in denser form, they may even be used to make pneumatic tires with a service life of several hundred thousand miles.

**Trademark*

The many faces of amine

Another versatile "soldier" in Dow's array of automotive chemicals, the amines serve the automotive industry as ethanolamine soaps, combined with soluble oils, for lubricating and cooling cutting tools . . . triethanolamine has been used as an anti-corrosion additive in antifreeze solutions and hydraulic brake fluid formulations . . . automotive polishes are based on ethanolamine derivatives . . . and amines are also used as acid neutralizers in oil filters. In short, the amines are one of the vital links in the chain between the automotive industry and Dow automotive chemicals research.

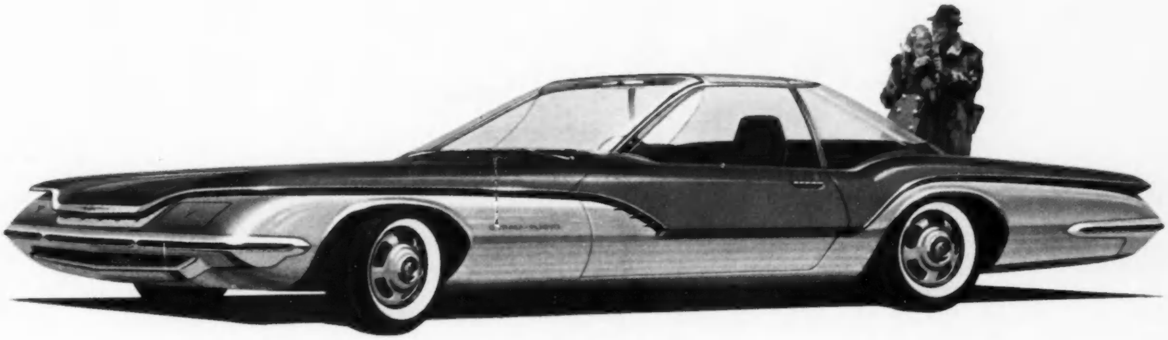


Coolant solutions subjected to a battery of corrosion tests.

• INFORMATION, PLEASE: If you'd like more information on the above activities, or any area of Dow's automotive research, please write us. A member of our technical staff will give your inquiry prompt attention. Write: THE DOW CHEMICAL COMPANY, Midland, Michigan, Chemicals Merchandising Department 401EN5; or contact a Dow sales office near you.

See "The Dow Hour of Great Mysteries" on NBC-TV

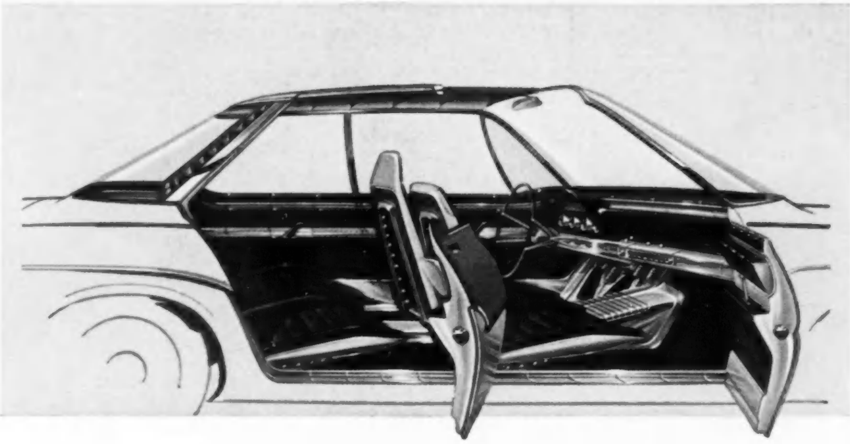
THE DOW CHEMICAL COMPANY
Midland, Michigan



stainless steel

No other metal has the strength, beauty and versatile qualities that serve you so well today and promise so much for tomorrow.

There is nothing like stainless steel for AUTOMOBILES



McLouth Steel Corporation,
Detroit 17, Michigan

Manufacturers of high quality Stainless and Carbon Steels

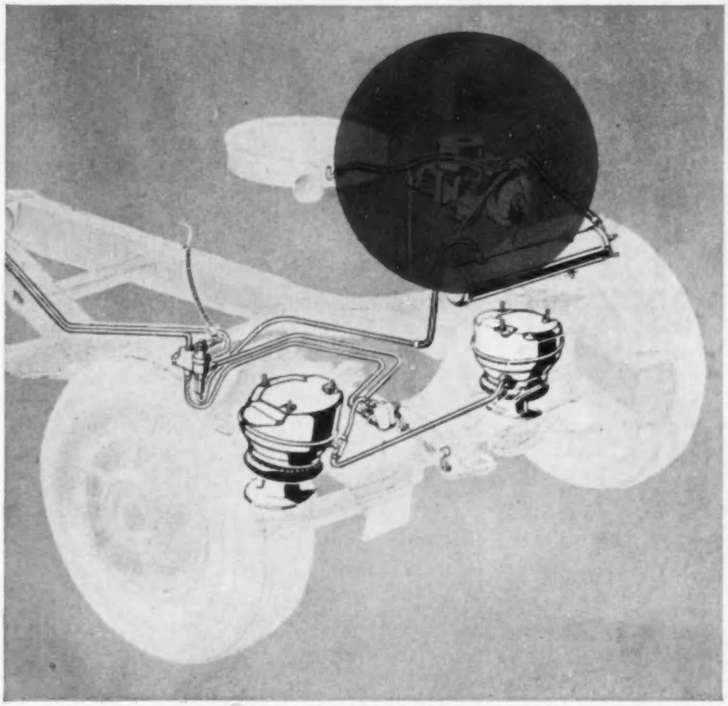
Look for the **STEELMARK** on the products you buy.

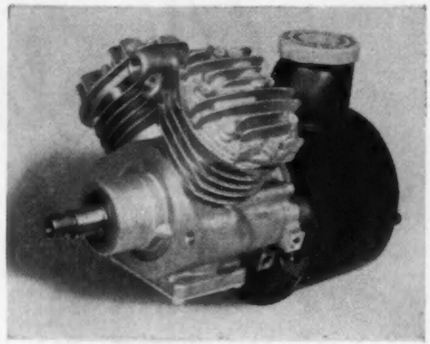
McLOUTH STAINLESS STEEL

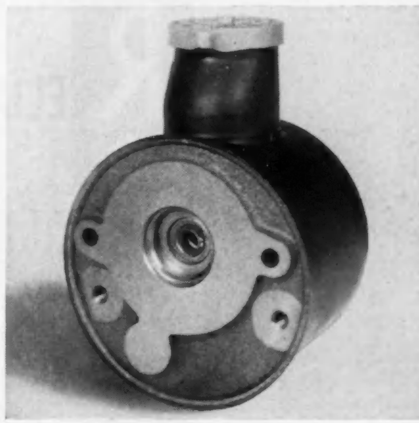
Naugatuck PARACRIL OZO

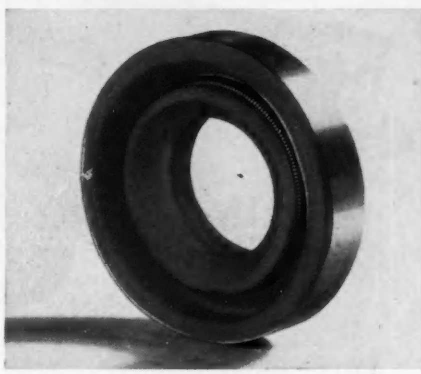
SILICONE NEWS from Dow Corning

Seals Hot Oil, Stays Springy









SILASTIC® SILICONE RUBBER Keeps Fluid in Place at –30 and 350 F

Here is a rubbery material that resists automotive hydraulic fluid and stays springy over a wide temperature range. It's Silastic, the Dow Corning silicone rubber, and it's doing rugged duty in some new cars.

Automotive engineers designed the dual device shown above. It consists of an air compressor and a pump assembly, operating in tandem off the same drive shaft . . . one pumping a synthetic hydraulic fluid to the power steering system, the other compressing air for pneumatic suspension. Obviously, some sort of seal was necessary to prevent fluid from leaking along the shaft from the pump into the air compressor. Because of possible shaft wobble or misalignment, the seal had to be flexible.

To solve the problem, they engineered a floating oil seal of Silastic. Thanks to the properties of Silastic, this seal works beautifully despite rpm's up to 6,000 and operating temperatures up to 350 F. The Silastic is also completely flexible at —30 F and is actually suitable for use from —130 to 500 F. The engineers are so pleased with the field performance of Silastic that they're now considering extending its use to many other new product design areas.

If you have need of such a flexible, durable material, investigate Silastic. Your rubber fabricator can engineer a part to your specifications. Or, for data, write Dow Corning, Dept. 9105.

Typical Properties of Silastic for Seals

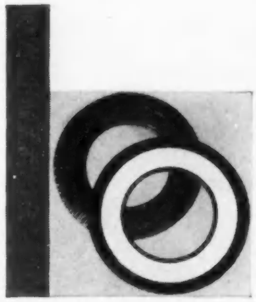
Temperature range, F	—130 to 500
Tensile Strength, psi	600 to 1400
Elongation, %	150 to 300
Tear Strength, lb/in	40 to 180
Compression set, % @ 300 F . .	5 to 50
@ 450 F . .	60
Hardness Range, durometer . .	20 to 80

If you consider *all* the properties of a silicone rubber, you'll *specify Silastic.*

first in silicones

Dow Corning CORPORATION
MIDLAND, MICHIGAN

ATLANTA BOSTON CHICAGO CLEVELAND DALLAS LOS ANGELES NEW YORK WASHINGTON, D. C.



HYPALON®
SYNTHETIC RUBBER

...the best answer to many automotive design problems

HYPALON synthetic rubber provides qualities not available in conventional elastomers for automotive design problems. HYPALON can be compounded to give a completely ozone-proof and color-stable elastomer with excellent weather, abrasion, oil and heat resistance.

This unique combination of properties has made HYPALON the choice of many design engineers for a variety of automotive applications—ignition cables, spark plug boots, coatings for door and deck lid seals, coatings for headliners, replacement convertible tops, and for white tire sidewalls.

Investigate the design advantages of HYPALON. It is currently being used for coating fabrics, for molded and extruded goods and for solution coatings in a range of nonstaining colors. For more information, call your rubber supplier or write E. I. du Pont de Nemours & Co. (Inc.), Elastomer Chemicals Department SAE5, Wilmington 98, Delaware.

DU PONT
REG. U. S. PAT. OFF.

SYNTHETIC RUBBER
NEOPRENE HYPALON® VITON® ADIPRENE®

Better Things for Better Living . . . *through Chemistry*

The most efficient, 2-stage air filter today is made by PUROLATOR

Simplicity of design makes the first cost of Purolator's new dry-type two-stage air filter as low as any 2-stage filter on the market. Yet it filters better than any other—99.98% efficient. Users save money and get better engine protection from this new Purolator filter, too. The first stage element will last up to 2000 hours, depending on operating conditions. The second stage will usually last almost indefinitely if the first element and sealing gaskets are maintained properly.

Both elements filter uniformly, in depth, over their whole surface, because they're both precision made of plastic-impregnated cellulose. Both elements are rated from 450 to 1150 cfm, with exceptionally low initial restrictions. Mounting straps, rainhoods and outlet adapters are available for field installation. The filter comes in all the most-used sizes.

For more information write to Purolator Products, Inc., Department 3450, Rahway, New Jersey.

Purolator Products, Inc.
Dept. 3450, Rahway, New Jersey

Please send me complete data on the new Purolator two-stage filter series.

Name_______________________________ Title_______________

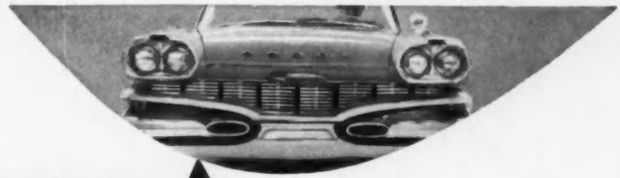
Company____

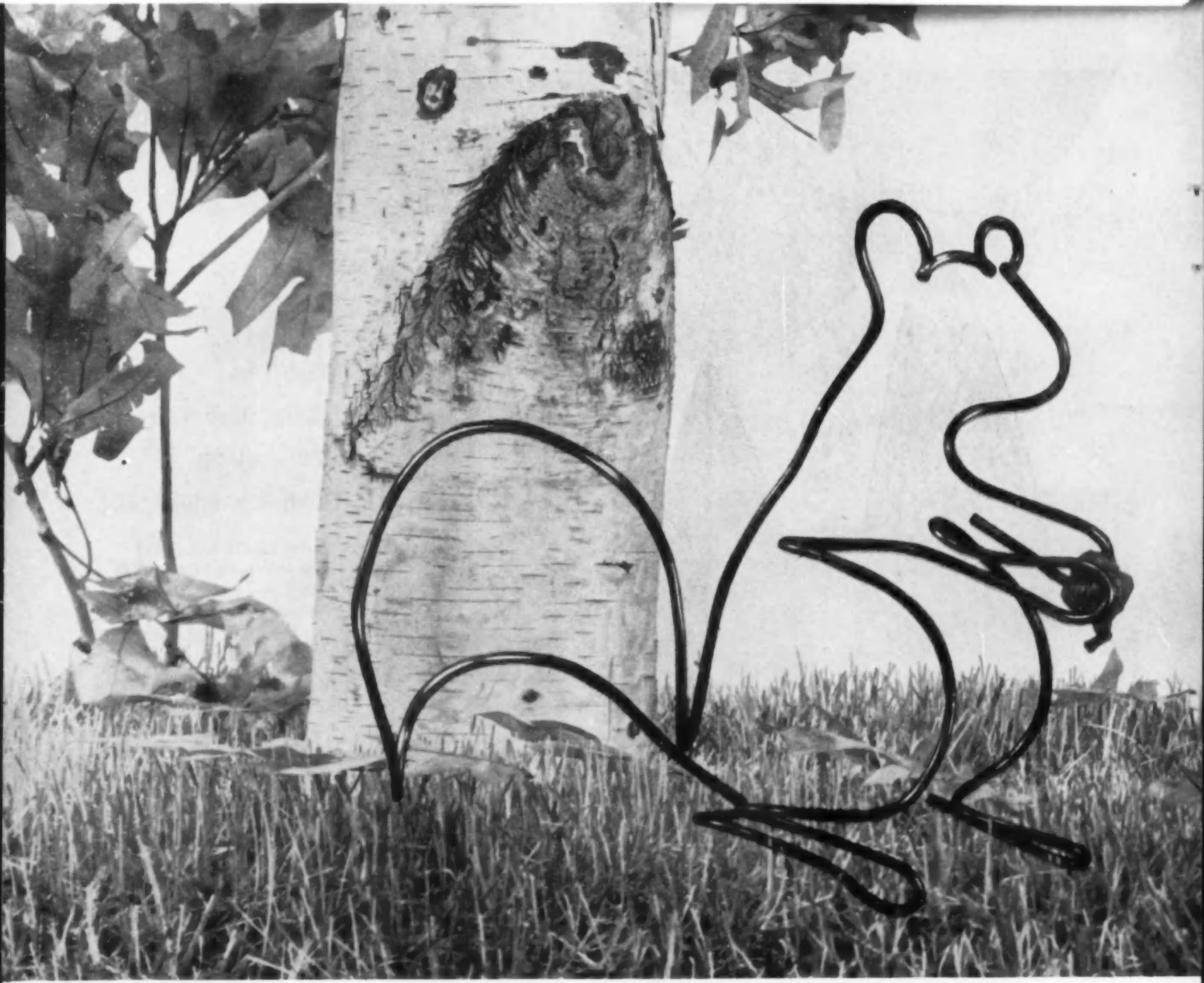
Address____

City________________________ Zone__________ State__________

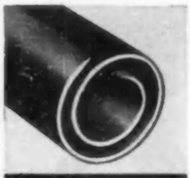
Filtration For Every Known Fluid

PUROLATOR
PRODUCTS, INC.
RAHWAY, NEW JERSEY AND TORONTO, CANADA

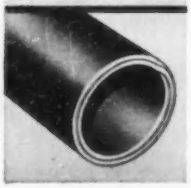




There's almost no limit to the things Bundy can mass-fabricate



Bundyweld is the only tubing double-walled from a single copper-plated *steel* strip, metallurgically bonded through 360° of wall contact for amazing strength, versatility.



Bundyweld is lightweight, uniformly smooth, easily fabricated. It's remarkably resistant to vibration fatigue; has unusually high bursting strength. Sizes up to ⅝" O.D.

Maybe your tubing problems don't run to animal shapes, but it's likely that you can benefit from Bundy's experience in mass-fabricating complex tubing parts. Here's why:

Precision bending: Bundy-developed machines turn out parts to exacting customer specifications . . . *with mass-fabrication savings.*

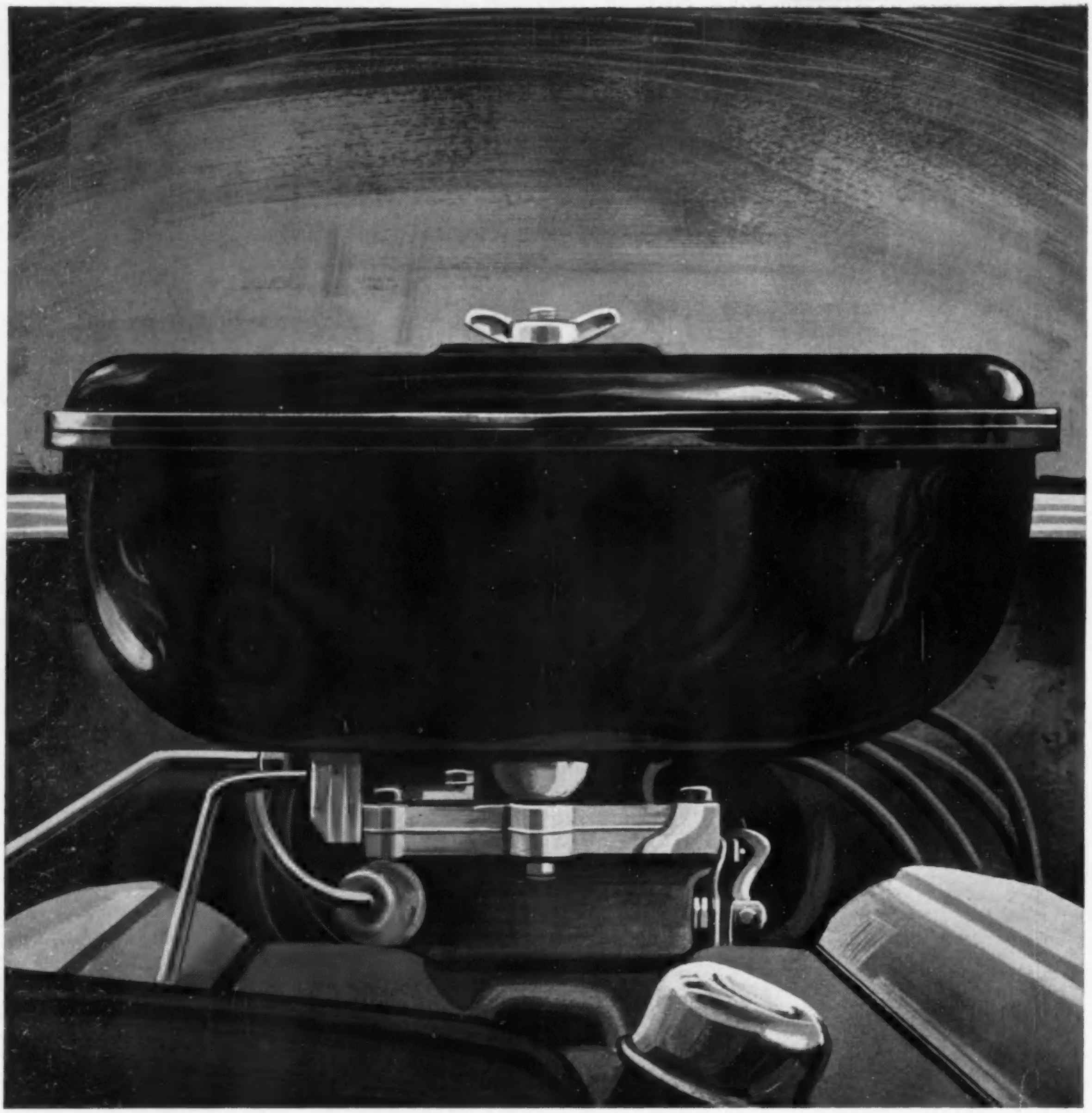
Great strength: Your component will be fabricated from Bundyweld®, the copper-brazed steel tubing that's *double-walled* from a single steel strip. Bundyweld, the tubing standard of the automotive industry, is used in over 95% of today's cars.

Expert design service: You can call on our engineering staff at any time to help with the design of your product. We may be able to point out short cuts that save you money without compromising engineering standards. Covered by Government Spec. MIL-T-3520, Type III.

Next time you have a tubing problem, better call Bundy *first*. Phone, write, or call Bundy Tubing Company, Detroit 14, Michigan.

highburstingstrength. Sizes up to ⅝" O.D.

Next time you have a tubing problem, better call Bundy *first*. Phone, write, or call Bundy Tubing Company, Detroit 14, Michigan.



THE NEW PHENOLICS

Let your ideas for tomorrow take shape in a host of hard-working materials • When you're getting ready to break with tradition, take a look first at the *new* phenolics.

Then lift the hood. You'll find a lot of places where you can put today's phenolics to work.

They're huskier; impact strength is up—as high as 15 ft.-lb. per inch. They resist heat as high as 500°F. Electrical properties, always good, are still better now—and improving all the time.

Idea: Did you know you can get Durez phenolics designed specifically for wet-on-one-side, dry-on-the-other situations? Think what that might mean in terms of *noncorroding hose connectors.*

Idea: How about a low-cost *distributor bowl case* of medium-impact phenolic? A nonrusting enclosure for accessory motors? A phenolic *air cleaner bowl* that hushes rattle and vibratory hum?

Idea: Or consider what you could do with a Durez glass-filled phenolic that outlasts metal in *oil-pump gears* and *automatic transmission parts.*

Remember, too, that when you design with phenolics you almost always save money. They can save you the whole cost of machining and finishing a part. They're low in price, stable in price, always available.

These newer, harder-working materials come from Durez in hundreds of formulations—give you a variety and a versatility that let you dream a little. To put the touch of tomorrow in today's design, come to Durez for *plastics that take you where other plastics can't go.*

For descriptive Bulletin D400 or for help on a specific application, write us.

DUR   PLASTICS DIVISION

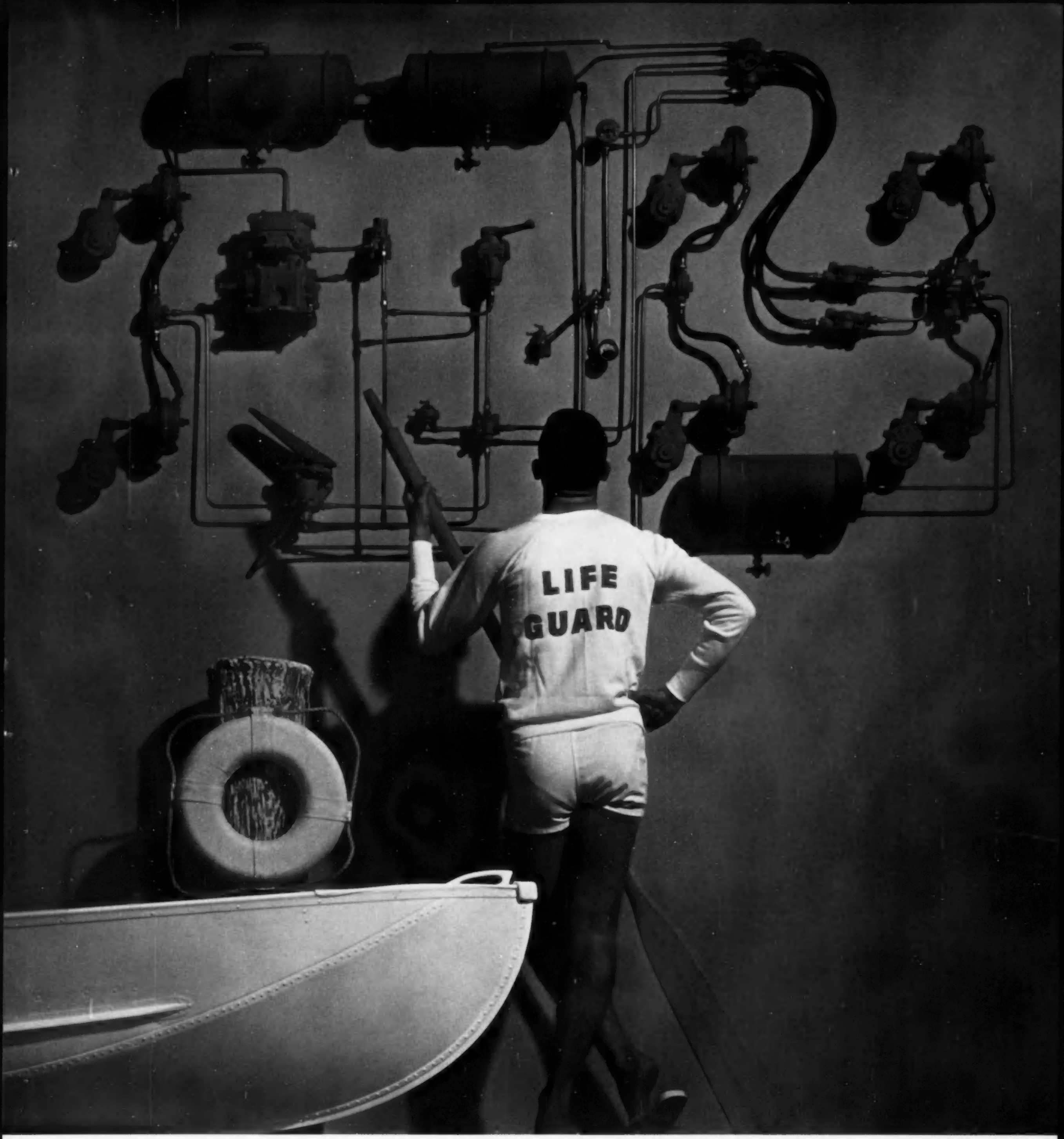
8105 Walck Road, North Tonawanda, New York

HOOKER CHEMICAL CORPORATION

HOOKER CHEMICALS PLASTICS

WORLD'S LARGEST PRODUCER OF SMALL-DIAMETER TUBING • AFFILIATED PLANTS IN AUSTRALIA, BRAZIL, ENGLAND, FRANCE, GERMANY, AND ITALY

BUNDY TUBING COMPANY • DETROIT 14, MICH. • WINCHESTER, KY. • HOMETOWN, PA.



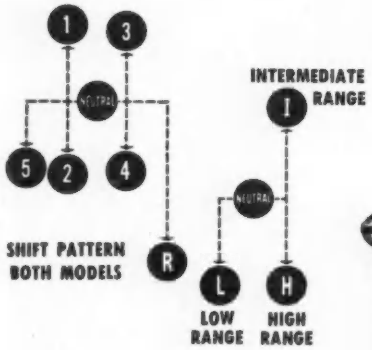
"SYSTEMATIC" SAFETY . . . at the beach, the lifeguard follows a planned system in protecting lives. On the highway—or off the road—it's air brake systems by Bendix-Westinghouse that guard the lives and loads aboard transport vehicles. Because these air brakes are system-engineered, they provide surer safety . . . plus utmost economy and dependability. For these reasons, the nation's fleet operators and vehicle manufacturers specify complete air brake systems from Bendix-Westinghouse. When it comes to new vehicles, these systems are your assurance of best all-around braking performance.

SPECIFY COMPLETE AIR BRAKE SYSTEMS BY Bendix-Westinghouse

BENDIX-WESTINGHOUSE AIR BRAKES ®

NEW Fuller Heavy-Duty

10 closely-spaced gear splits plus deep reduction ratios



MODEL 15-G-1120

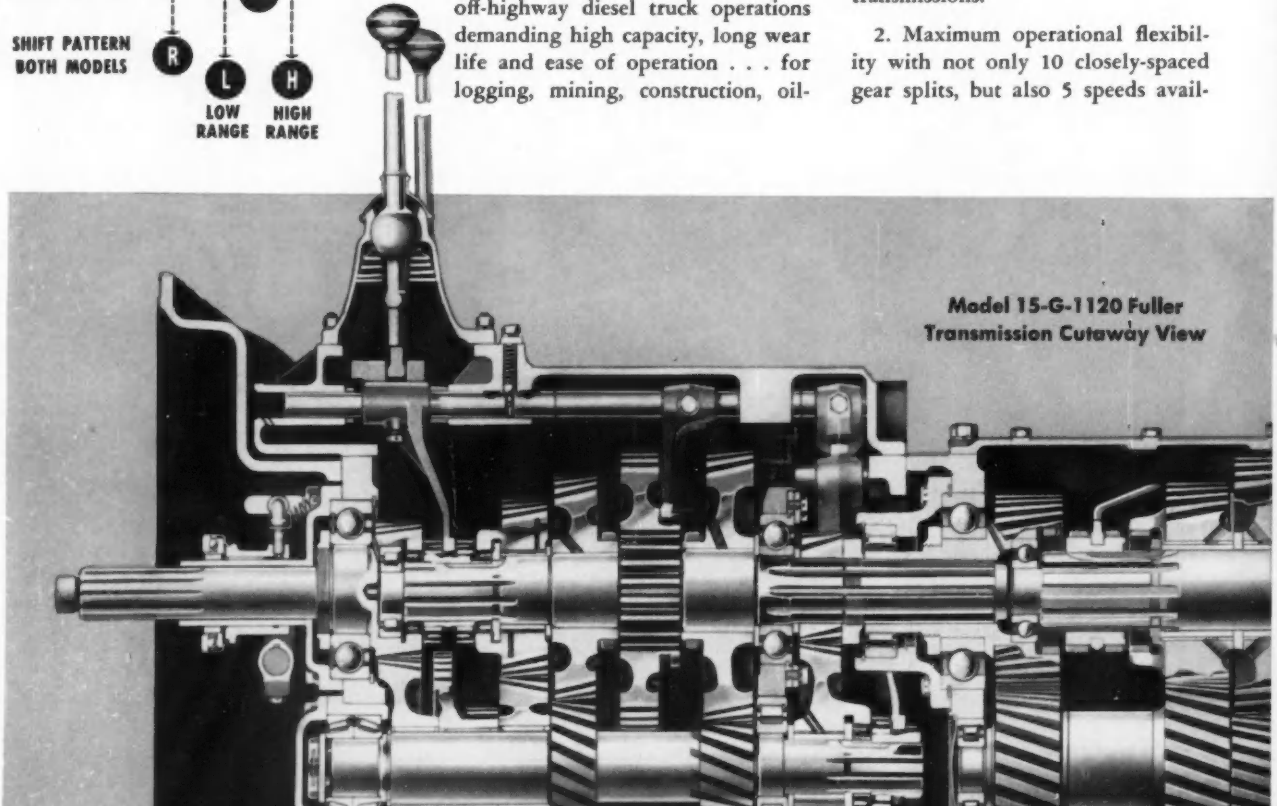
MODEL 15-H-1120

Fuller now offers two new 15-speed transmissions engineered for on and off-highway diesel truck operations demanding high capacity, long wear life and ease of operation . . . for logging, mining, construction, oil-field work, aggregates and ready-mix.

Advantages of the new transmissions include:

1. Extremely short installation dimension, which permits shorter wheelbase for tractors which formerly incorporated main and auxiliary transmissions.

2. Maximum operational flexibility with not only 10 closely-spaced gear splits, but also 5 speeds avail-



Model 15-G-1120 Fuller Transmission Cutaway View

FULLER — TRANSMISSION DIVISION — MANUFACTURING COMPANY KALAMAZOO, MICHIGAN

Unit Drop Forge Div., Milwaukee 1, Wis. • Shuler Axle Co., Louisville, Ky. (Subsidiary) • Sales & Service, All Products, West. Dist. Branch, Oakland 6, Cal. and Southwest Dist. Office, Tulsa 3, Okla. Automotive Products Company, Ltd., Automotive House, Great Portland Street, London W.1, England, European Representative

15-SPEED TRANSMISSIONS

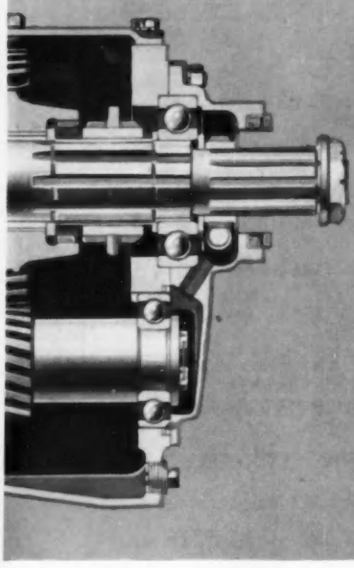
designed for combination on and off-highway applications

able for low range operation through a deep reduction in the auxiliary.

3. A wide choice of optional gear ratios to match every job requirement.

4. Weight reduction obtained by eliminating support brackets, joints, cross members and a propeller shaft.

For full details on the Fuller 15-G-1120 and 15-H-1120 Transmissions, ask your dealer or write Fuller Manufacturing Company.



Subsidiary of EATON Manufacturing Company

Model 15-G-1120: Standard Gear Ratios

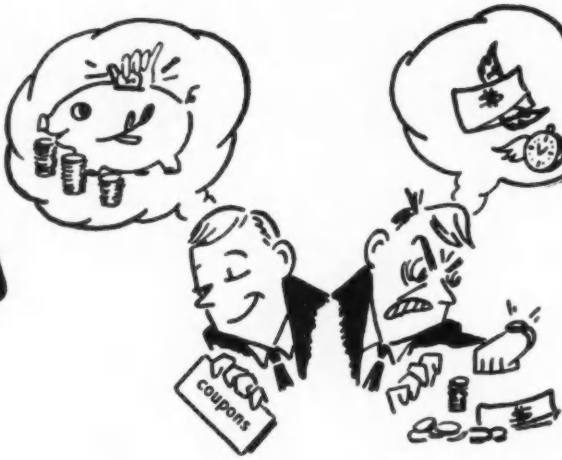
SPLITS—OVER-HIGHWAY				LOW RANGE—OFF-HIGHWAY		
Speed	**Split**	**Ratio**	**% Step**	**Speed**	**Ratio**	**% Step**
10th	O'Drive-High	.636		5th-Low	1.33	
			33			
9th	O'Drive-Int.	.844				57
			19			
8th	Direct-High	1.00		4th-Low	2.09	
			33			
7th	Direct-Int.	1.327				76
			32			
6th	3rd-High	1.76		3rd-Low	3.68	
			33			
5th	3rd-Int.	2.32				86
			41			
4th	2nd-High	3.27		2nd-Low	6.83	
			33			
3rd	2nd-Int.	4.33				100
			51			
2nd	1st-High	6.54		1st-Low	13.67	
			33			
1st	1st-Int.	8.68				

Model 15-H-1120: Standard Gear Ratios

SPLITS—OVER-HIGHWAY				LOW RANGE—OFF-HIGHWAY		
Speed	**Split**	**Ratio**	**% Step**	**Speed**	**Ratio**	**% Step**
10th	O'Drive-High	.636		5th-Low	1.68	
			33			
9th	O'Drive-Int.	.844				57
			19			
8th	Direct-High	1.00		4th-Low	2.64	
			33			
7th	Direct-Int.	1.327				76
			32			
6th	3rd-High	1.76		3rd-Low	4.65	
			33			
5th	3rd-Int.	2.32				86
			41			
4th	2nd-High	3.27		2nd-Low	8.63	
			33			
3rd	2nd-Int.	4.33				100
			51			
2nd	1st-High	6.54		1st-Low	17.27	
			33			
1st	1st-Int.	8.68				

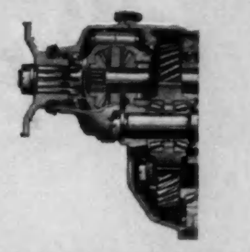
Optional Gear Ratios: Models 15-G-1120, 15-H-1120

Overdrive: .85, optional at extra cost
Overdrive: .74
Reverse: 5.06

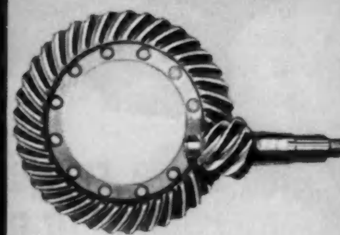

coupons

MORE THAN 200 MILLION EXTRA TON-MILES OF PAYLOAD IN JUST 5 YEARS

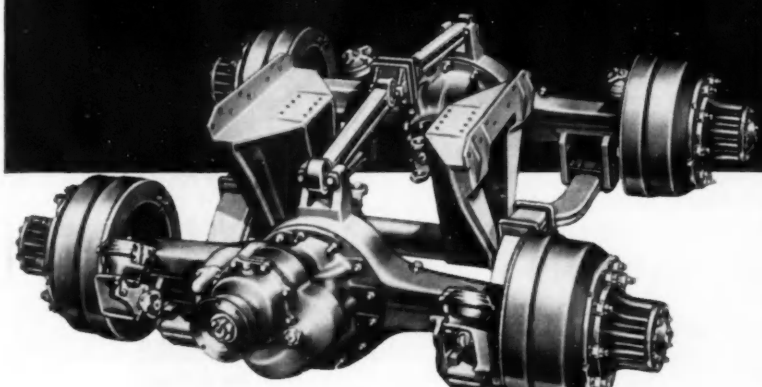
WITH TIMKEN-DETROIT® LIGHTWEIGHT TANDEMS

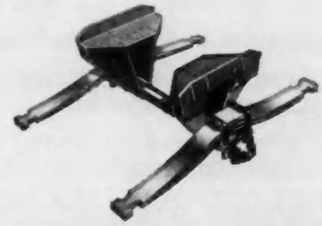


Driver Controlled Inter-axle Differential. Allows differential action between the axles to compensate for worn or mismatched tires . . . both axles do equal amounts of work. Can be dis-engaged at any speed giving positive thru-drive when better traction is needed.



Stronger Gear Sets. Hypoid gearing provides up to 30% more strength than spiral bevel gears of the same size. Modern hypoid design allows larger and stronger pinions with greater tooth contact area . . . assuring top efficiency and long life.





New Suspension Pushes Tandem Weight Savings Over 1000 Lbs. Rockwell-Standard's "taper-leaf" springs coupled with the latest in balanced suspension system designs is up to 475 lbs. lighter than comparable units. When combined with the payload advantages of the Lightweight Tandem you can save more than 1000 pounds per trip. This means thousands of ton-miles in extra payload per year.

In the five years since Rockwell-Standard introduced Timken-Detroit Lightweight Tandems, thousands of users have rolled up millions of extra ton miles of payload. Check the superior features illustrated at right. They are some of the reasons why these axles are first choice with over-highway operators:

Plus these additional Timken-Detroit advantages:

- In-line drive reduces wear on working parts
- High degree of parts interchangeability
- Large selection of gear ratios
- Torsion-Flow axle shafts
- Wide range of capacities — 8 models from 22,000 to 44,000 pounds

Another Product of... **ROCKWELL-STANDARD CORPORATION**

ROCKWELL R STANDARD ®

Transmission and Axle Division, Detroit 32, Michigan

Throughout the entire field

of liquid-cooled engine design . . .

DOLE THERMOSTAT ENGINEERING ASSURES POSITIVE TEMPERATURE CONTROL

Every manufacturer knows that engine performance will be improved if it operates at the most desirable temperature during every season of the year. That's why designers have been specifying Dole Thermostats for accurate, dependable temperature control ever since liquid-cooled engines were proved to operate at optimum efficiency when equipped with thermostatic heat control devices.

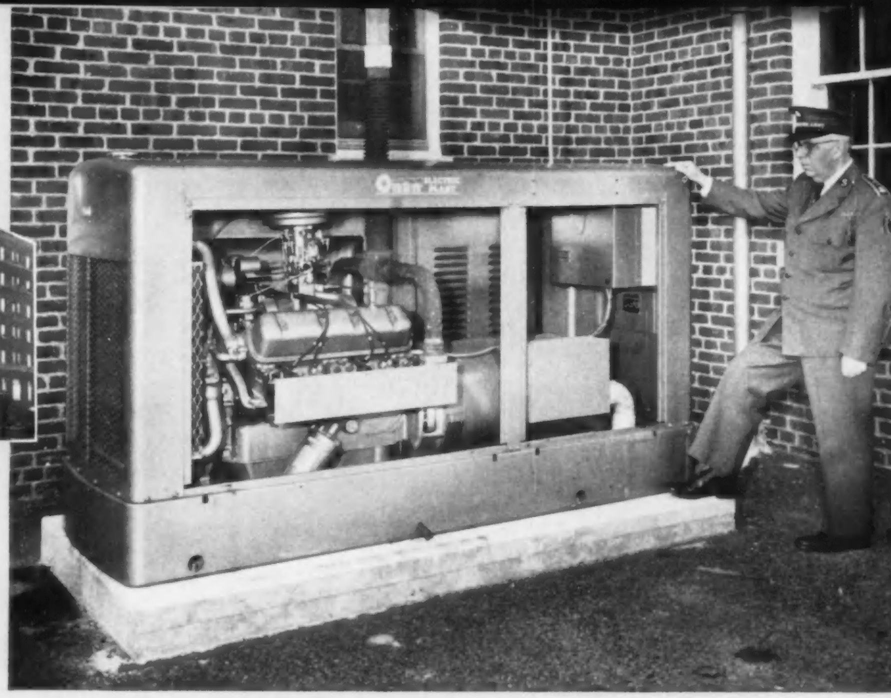
For every internal combustion engine, from the smallest marine inboard or outboard to the most complex passenger car or truck engine, *regardless of design*, there's likely a Dole Thermostat now keeping it running at peak effectiveness. But, what's more important, if a Dole Thermostat is not presently available to meet your specs—Dole will design and build one for you.

Dole has been doing just that for years—engineering thermostats as component parts for every type of engine across the field. Possibly we could help improve your product—we'd like to try. Write to: Automotive O.E.M. Products Sales Dept. 636, New Center Bldg., Detroit 2, Mich.

Control with

DOLE®

Automotive OEM Products Sales Department
The Dole Valve Company
6201 Oakton St., Morton Grove, Ill. (Chicago Suburb)



Salvation Army Retired Officers' Residence at Asbury Park, N. J. relies on Onan 85,000-watt Model 85KR-4R-1A standby unit for emergency electric generating power. Onan, in turn, relies on International UV-549 engine for never-fail performance of the generating plant. SA Brigadier G. E. Ciscombe is shown with unit.

D. W. ONAN, a leading producer of air-cooled engines, chooses INTERNATIONAL®

WHEN SPECS CALL FOR WATER-COOLED POWER

Report from Vice President-Engineering, J. C. Hoiby, D. W. Onan & Sons Inc., Minneapolis, Minn.

V.P. Hoiby says, "Onan equipment is built for 100% dependability. That's why we have chosen International gasoline engines to power our 60 kw and 85 kw standby generating plants. With such a dependable power source Onan customers need never worry about power outages. International also gives us the advantages of an excellent parts and service organization."

Here's another major manufacturer who knows the built-in benefits of International power. D. W. Onan & Sons Inc., producers of a famous line of air-cooled engines and heavy-duty generating equipment, rely on an International gasoline engine for this 85,000-watt standby electric plant. In case of commercial power interruption, this unit cuts in automatically and supplies power for the entire Salvation Army building. In addition to furnishing standby power for all lights in the building, the plant also serves laundry equipment, elevators, oil burner, water pump, and electrical cooking.

If you haven't joined the long list of International power users, you may be passing up an extra selling advantage for your product. So learn all about the IH line—35 engines from 16.8 to 385 max. hp—with choice of fuels, and interchangeability in size and power, to match your requirements. For detailed information contact International Harvester Co., Engine Sales Dept., Construction Equipment Div., Melrose Park, Ill.

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International Harvester Co., 180 North Michigan Ave., Chicago 1, Illinois

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+ INDEX TO ADVERTISERS +

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KEEPS ENGINES POWERFUL LONGER—AT LOWER COST

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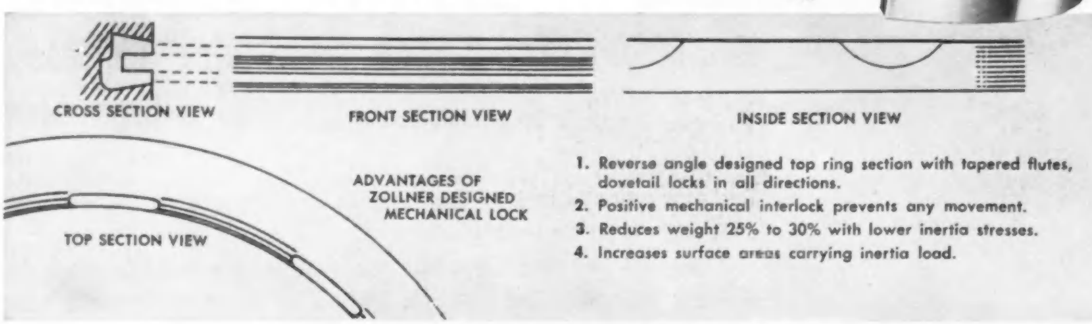
METALLURGICALLY A1-Fin Process — MECHANICALLY Zollner Lock

Design adaptable to any type pistons

Stops Ring Groove Wear

Everywhere, engine builders and transport operators enthuse over the performance of Zollner Bond-O-Loc Pistons — "The greatest mileage piston we have ever used. Top ring groove wear problems are eliminated by the 'Ni-Resist' Iron section **permanently** incorporated with the double bond of both A1-Fin metallurgic **and the exclusive** Zollner mechanical lock." For longer piston life, better performance and lower maintenance cost, we suggest your immediate test of Bond-O-Loc advantages.



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3. Reduces weight 25% to 30% with lower inertia stresses.
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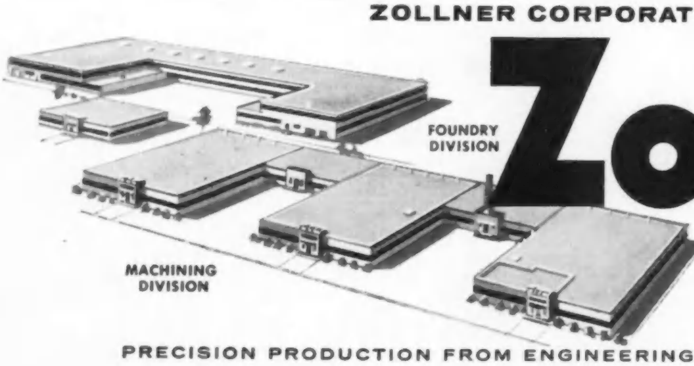

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